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CONTENTS.

	PAGE
The Petroleum Industry.—III. By George T. Holloway, assoc. R.C.S. (lond.), F.I.C. (*Illustrated*)	169
An Old-World Highland. By Grenville A. J. Cole, M.R.I.A., F.G.S. (*Illustrated*)	170
Self-Irrigation in Plants.—II. By the Rev. Alex. S. Wilson, M.A., B.SC. (*Illustrated*)	173
Celebes: a Problem in Distribution. By R. Lydekker, B.A., F.R.S.	175
British Ornithological Notes. Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.	177
"Insect Miners." By Fred. Enock, F.L.S., F.E.S., etc. (*Illustrated*)	178
Notices of Books	179
Short Notices	180
Books Received	181
Letters:—J. H. Jenkinson (*Illustrated*); W. H. S. Monck; H. Whichello; W. Wesché	181
Artificial Faculæ. By the Rev. Arthur East. *(Plate)* ..	183
The Objective Prism, the Flash, and the Reversing Layer. By E. Walter Maunder, F.R.A.S. (*Illustrated*)	184
Alexander Goodman More	187
How to Photograph through a Fly's Eye. By Fred. W. Saxby. (*Illustrated*)	187
Notes on Comets and Meteors. By W. F. Denning, F.R.A.S.	189
The Face of the Sky for August. By A. Fowler, F.R.A.S.	191
Chess Column. By C. D. Locock, B.A.	191

THE PETROLEUM INDUSTRY.—III.

By George T. Holloway, assoc. R.C.S. (lond.), F.I.C.

IT was not until 1859 that the use of petroleum for illuminating purposes commenced to be general, although lamps for burning the very similar coal oil and shale oil had been introduced some six or seven years previously by Stobwasser, of Berlin, and by Young's Paraffin Light and Mineral Oil Company of this country. Prior to the introduction of these oils, only animal and vegetable oils (excepting oil of turpentine, which was employed to some extent under the trade name "camphine") had been used; they possessed many of the qualities of tallow, and were capable of being burned with a small wick and with free exposure to the air. The petroleum oils, however, are of an entirely different nature, containing much more carbon and hydrogen than do the animal and vegetable oils, and are far more volatile and inflammable; they must be supplied in a regulated quantity to the flame, and with a proper amount of air, or a smoky and objectionable flame results.

The enormous number of lamps which are now in use, and the necessity for fixing an arbitrary limit for the volatility and inflammability of the oil which may be used in them, and the conditions under which the oil may be stored, conveyed, and sold, has given rise to much legislation in this and other countries. The differences in the laws of various countries on this subject show how difficult it is to decide on the standard which shall be at the same time safe for the consumer and fair to those who produce and supply the illuminant. As this matter is still under consideration by a committee of the House of Commons, it is not the intention of the writer to express an opinion on the subject; but it may be of interest to trace some of the more important steps in the evolution of the mineral oil lamp which have led to its present efficiency. It may, however, be taken as an axiom that no oil is safe in a badly constructed lamp, or when used by the careless.

The first important improvement which fitted lamps for use with mineral oils was the introduction, by Argand, of the chimney, by which the requisite draught of air was caused to impinge on the flame, and thus produce a greater efficiency as regards illuminating power and an absence of smoke. This was followed by the invention of Roberts, whose lamp, specially constructed for burning camphine, was fitted with a disc known as the "Liverpool button," which was fixed some distance above the circular wick, so as to deflect the air current downward upon the top of the flame. Next came the dome which fits over and round the wick, and has a slit through which the flame passes; this appliance, which is now fitted to practically all oil lamps, still further directs the air between the dome and the wick so that it is applied at the point of maximum efficiency. In the Wanzer, and certain other lamps, air is blown by clockwork or other device upon the flame. Finally, we have those lamps in which two or more wicks are employed, as flames thus impinging one upon the other give a greater light than when burned separately.

The principal danger with oil lamps lies in a badly fitting wick—which is liable to be dropped, while still alight, into the reservoir—and in the use of breakable vessels. Metallic reservoirs are now largely employed, and various safety appliances are attached to the best forms of modern lamps: for example, a flap or other appliance may close over the flame and extinguish it when the lamp is overturned or unduly tilted; and the cage of wire gauze, suggested by Mr. Boverton Redwood, in which the wick is enclosed so that no flame can pass from the wick to the oil in the reservoir. While most accidents are not due to a true explosion, but to the simple ignition of the oil through the overturning or breaking of the lamp, explosions may occur from the production of an explosive mixture of the vapour of the oil with air in the reservoir; and the question which has been so much under discussion of late hinges on whether this can be prevented by raising the "flashing" point of oil, or whether it can best be dealt with by insisting on the use of such lamps only as are properly suited for burning the oil as at present sold.

Legislation in this and other countries is mainly based on what is known as the "flashing" point, which means the temperature at which the oil gives off an inflammable vapour. This is, of course, lower than is shown by the fire test, *i.e.*, the temperature at which the oil itself will take fire.

The Acts of 1862 and 1868 in the United Kingdom included under the term "petroleum" such oil as gave off an inflammable vapour at less than one hundred degrees Fahrenheit by what is known as the open test—that is, when warmed in a vessel exposed to the air; but as this test was found to give varying results in different

hands, it was replaced in the Act of 1879 by the closed cup, or Abel tester, in which the oil is warmed in a closed vessel, and is only exposed to the air at the moment that the testing flame is applied. A series of tests made by Mr. Boverton Redwood on a thousand samples of American kerosene having proved that the Abel tester showed a flashing point about twenty-seven degrees *lower* than the open tester indicated, a "flash point" of seventy-three degrees Fahrenheit was decided upon, so that the actual flash point now recognized may be considered as identical with that originally decided upon over thirty years ago.

The Abel tester has been found so efficient and regular in the results it has yielded in the hands of different operators, that it has been legalized in many other countries, either in its original form or with some slight modifications. It is shown in Figs. 1 to 3, and consists of the metal cup, Figs. 1 and 2, into which the oil to be tested is poured up to a fixed point; an outer metal cup serving as a water bath, and an enclosing metal cylinder forming an air jacket. A lamp swivelled on one leg of the apparatus is also fitted to the tester (Fig. 3), and thermometers indicate the temperature of both the oil and the water.

The oil cup has three square holes in its cover which

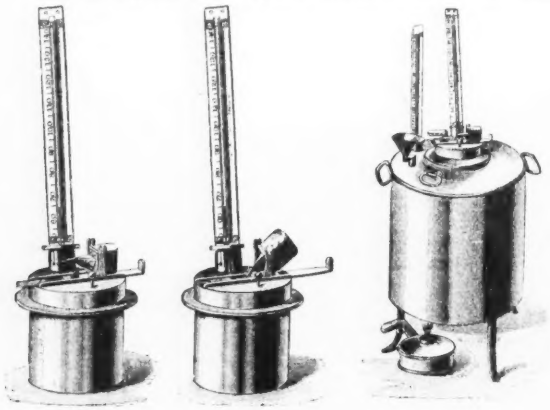

FIG. 1. FIG. 2. FIG. 3.

The Abel Tester for the "Flash Point."

are normally closed by a sliding plate having three corresponding openings. The slide is shown closed in Fig. 1 and open in Fig 2. It carries a pin, which, when the slide is opened, catches a small metal lamp swinging on pivots and tilts its nozzle downwards over the surface of the oil through one of the three openings, as shown in Fig. 2. This test lamp consists of a box with a hinged lid and a tubular nozzle, through which passes a tiny wick from the body of the lamp, which is charged with cotton wool saturated with oil. The wick is trimmed to give a flame exactly the size of the small bead shown at the end of a pin on the oil cup. All parts of the apparatus are made to a standard size, and are tested by the Weights and Measures Department of the Board of Trade before they may be used officially.

In using the apparatus, the water bath is first charged with warm water through the funnel shown, and the temperature brought to one hundred and thirty degrees Fahrenheit by the addition of hot or cold water or by use of the lamp beneath the apparatus. The oil cup is then charged with the oil to be tested, the little test lamp lighted, the lid of the oil cup closed, and its thermometer watched. A pendulum, twenty-four inches long, is then set swinging, and when the temperature of the oil has reached about sixty degrees Fahrenheit, the test is commenced. For each degree of rise in temperature the slide is drawn open slowly by hand while the pendulum makes three oscillations, and is closed during the fourth oscillation. When the flashing point is reached, a slight blue flame is seen to pass over the surface of the oil, and if this occurs at a temperature not lower than seventy-three degrees Fahrenheit, the oil is said to have passed the test.

In the application of this test everything depends on adherence to the specified conditions. Tables for variations in the atmospheric pressure must be used.

So many testers are or have been in use that it would be impossible even to give their names here, and the Abel tester has been selected as the one most generally employed.

For many technical and commercial purposes other tests have to be applied. Thus the analyst must sometimes employ chemical tests to ascertain freedom from sulphur compounds, etc.; distillation tests to ascertain the amount of the oil which volatilizes between certain temperatures; colour tests, in which, by means of Lovibond's tintometer, or Wilson's or Stammer's chromometer, the colour according to the commercial standards between "water white" and "good merchantable" is determined; viscosity tests, in which the value of the oil as a lubricant is ascertained; photometric tests to determine the illuminating power of the oil; and, finally, the odour test, by which an experienced operator can tell whether the oil has been properly refined and kept.

AN OLD-WORLD HIGHLAND.

By GRENVILLE A. J. COLE, M.R.I.A., F.G.S., *Professor of Geology in the Royal College of Science for Ireland.*

THERE is a corner of wilder Connaught, on the very border of Galway and of Mayo, where the features of the west of Ireland seem grouped together and epitomised. In a brief season of summer it is known to tourists as Leenane; but, in the more transparent and sunnier days of spring or autumn, the lover of quiet will find it a haven of content. Before the hospitable doorway, the sea stretches in gentle ripplings, at the head of a fjord which runs down west to open water. There is little suggestion here, whether the day be dark or clear, of the great surge that beats ever on the islands, on Inishbofin and lofty Inishturk, ten miles away in the Atlantic. Northward lies the mountain-land of Mayo, a district as large as Sutherland, over-populous on its seaboard, yet wild and desolate within. Southward lies the still finer highland of Galway, a land of peaks, and terraced moorlands, and abundant lakes, into which even the broad Lough Corrib sends up romantic tongues of water. Except for one encircling road, these fastnesses east of the Twelve Bens, the barren valley of Bealanabrack, or the deep grey hollow of Lough Nafooey, are as little known to most of us as Corsica.

The remark has some appropriateness, for in these grim surroundings, without communications, girt about by the precipiced cirques of Formnamore, a race has grown up to whom the law of *vendetta* has seemed nearer and far simpler than the complex legality of the east. Cast down by years of failure, weakened by the emigration of the strong, driven by topographical details to repeated intermarriage, this population has presented the problem of an island cut off within an island. Nowadays the railways have crept nearer to the mountains; public bodies have employed both men and women in turning the unfenced tracks into some of the finest roadways in our islands;

and, when we are chatting at tea-time in the farms, or exchanging a greeting with some old peasant on the way, it is hard to recall or to realise the bitter stories of the glens. When, however, we turn off the mail-car routes, we perceive, even now, the isolation of this old-world highland. The vivid colouring of the costumes of the peasantry in itself shows lack of intercourse; English is but little spoken; and the women work out of doors, not only with the men, but for the men, as in the primitive countries of this world. But such scenes, and the strangeness of them, have high attractions for those who view them from without. Here, on a corner of the pass, comes a woman, her basket on her arm, riding over to one of the villages on Lough Mask. With her white cap, her deep red skirt, her shawl of

Fig. 1.—View up the head of the fjord of Killary Harbour, showing its continuity with the valley of the Erriff River. The tide is running out. The terraced scarp of the Formnamore group bounds the valley on the right. (From a photograph by Mr. R. Welch.)

brilliant hues, in which scarlet and crimson predominate, she forms a vision of colour against the moorland, such as one scarcely looks for short of the Hungarian east. Down below, a sober distance in advance, we see her master, also riding, and gathering the week's news by calling to his friends, it may be a field or two away. Behind us, a grey rain-drift creeps up across the Joyces' country; on the left, the huge wall of Maamtrasna rises so sheer that it seems in the gloom to overhang; while, in front and below, the great lake stretches, white, like a sea, into the plain.

Behind these obvious features lies a long geological history; and it is the history of the whole north-west of Ireland. The rocks that are now laid bare belong mainly to the old "Caledonian" chains; that is to say, they were upheaved and folded at the close of Silurian times. Here and there, we have proofs that they sank in part beneath the Carboniferous sea, and were again upraised during the great "Hercynian" movements. One or two patches of Carboniferous sandstone and conglomerate remain as outliers on the heights around Maamtrasna, that on Ben Wee now lying at an elevation of more than two thousand feet.* The mountains that were lost for a time beneath the waves have reasserted themselves, and have thrown off the covering of Carboniferous deposits; and we find exposed at their bases the still older surface on which their own materials were laid down.†

The prominent stratified rocks on either side of the fjord of Killary Harbour are the Ordovician conglomerates. These can be studied in almost every fallen block along the shore for miles west of Leenane; on the gentler slopes of Ben Gorm across the water; and, to name no other region, in massive exposures, worn by glaciation, on the steep descent to Lough Nafooey. Few rocks are more handsome in themselves; few tell better the tale of long waste and denudation, as the oldest Irish land gave way before the breakers of an Ordovician sea. The great

* Memoir to Sheets 73, 74, 83, and 84, *Geological Survey of Ireland* (1876), p. 53. The later annual reports of the Survey include a considerable revision of the Killary district. See that for 1896, pp. 49 to 51 (published in 1897).

† These older rocks are part of the conveniently named *Dalradian* group of Sir A. Geikie.

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pebbles often lie well separated in a dark green-grey matrix of coarse sand. Among them are granites, and quartzites, and compact flinty lavas—evidences of the long gap that divides them from the underlying igneous and metamorphic series. The beds below are more highly tilted, and everywhere the unconformity is a marked one. The ancient land, the floor of the country, at whatever period it first arose, was pierced by igneous masses, and was baked and altered; its shales became slates and schists, its limestones marbles; and the invading rocks had cooled down in the form of granite before the period of denudation occurred that formed the conglomerates of Killary Harbour. In this area, then, we have the old land of unknown age, perhaps even a remnant of the pre-Cambrian chains; it comes rapidly into view as we go south along the Joyces' River, and culminates in the quartzite ridges of the Maam Turk Mountains and the Twelve Bens. Then we have the grand scarps and cirques of Formnamore, and the impressive and close-set group of summits that form the Mweelrea range on the north side of the fjord; these represent the thick deposits on the Ordovician and Silurian shoreline, in a sea that lay open to the north.* Then came the widespread Caledonian movements. In Devonian times, our highland was thus already well established, looking down into lake-basins that lay many miles away on the north-east and the east; and then a second great subsidence brought it below the Carboniferous sea, and for a time saved it from denudation. We do not know when it made its next appearance; but probably the covering was worn away from its bolder summits soon after the uplift of the Hercynian chains.

The complex details have even yet to be worked out; but the district is clearly one of those that have remained highlands by the force, as it were, of pure tradition. Many parts of the west of Scotland, the English Lake District, the volcanic precipices and *arêtes* of Wales, have similarly proved their powers of resistance, and their tendency to reappear as knots through any covering forced upon them. In this they resemble Suess's favourite "horsts" of Central Europe; and it is easy to predict that they will remain as the bare skeleton of Britain, long after the films of the London Clay, the Chalk, or the soft Triassic sandstones, have been washed away into the North Sea and the Channel.

The vitality of Ireland similarly lies in the great ribs of the west, holding their own against the Atlantic and its warm soft air. Even if the oscillations of the continental edge again submerge her, Connaught will still exist, a core of mountains, in the depths.

At present, the stratification of the series of rocks out of which the hills have been carved is still well marked around us. The north scarp of the Formnamore group is seen in Fig. 1, where the terraces of Ordovician and Silurian strata form a feature of the steep hillside. In Tonalee, again, above the Maam valley, the unconformity between the old "Dalradian" series and the overlying Ordovician conglomerates is traceable even at a distance.

North of Killary Harbour, a road traverses the Mweelrea Mountains by a low pass, and brings us into the most exquisite landscapes of the range. For two miles, along the west shore of Lough Doo, the purple crags of Glancullin, ledged with green, rise some two thousand five hundred feet above the water, and the steep southerly dip of the beds adds to the serration of the mountain-face. The scene is even finer if we turn up the valley to the east, and view it from the moorland level, with Doo Lough answering to its name, and lying black below us.

* See Sir A. Geikie, *Ann. Rep. Geol. Survey for 1896*, p. 51.

Still further to the east, the Dalradian floor is met with in the lonely bogland through which Lough Tawnyard extends. Here the fine cirques and mountain-crests are still formed of the upper stratified series, the masses of which rise in great outliers upon the worn-down edges of the older rocks.

We have already hinted at the prominence of the floor itself, the "pre-Caledonian" ridges, in the fine region of the Twelve Bens of Connemara. If we follow the fjord of Killary down to its mouth, we can look across thirty miles of blue but restless water, until the eye is caught by the huge cone on Achill Island; this is cut in half on its west side, where its cliffs drop more than two thousand feet into the sea. Here, again, the older series still asserts itself, bared from any covering of Silurian or Carboniferous deposits.

As we return eastward up the inlet to Leenane, the strange aspect of the fjord itself is impressed upon us, and our thoughts are transferred to the most recent of geological epochs. The deep groove-like nature of the hollow that is occupied by the sea is well seen as we climb the moors upon the south; and thence we look down into the water, where the fresh tide has covered all the sandbanks, and has pressed back the flow of the river with a curving line of foam. This groove is ten miles long, and is rarely more than half a mile in width. At its head (Fig. 1) it passes continuously up into the valley of the Erriff, which is bounded by the same steep green or cliff-set walls.

At the hamlet of Aasleagh, where we reach the actual river, there is a pleasing little waterfall over a step in the valley-floor; and below it there is a second tumbled fall, where the seaweeds and the wild-flowers meet, and where the former clothe all the rocks out in the stream. Here we see the excavation of the valley still going on.

But this is only a feature of low water. At high tide the sea reaches the bridge of Aasleagh, and the clump of fir trees looks down upon ephemeral waves. All evidence of the activity of the river on its rocky bed has disappeared.

There is at this point an obvious connexion between the valley and the marine inlet. As the river, in the interspaces of low water, erodes its bed, the sea can spread further, though imperceptibly, inland at each successive tide. Will not this cutting back of the head of the fjord, year by year, account for the long intrusion of the sea upon the land?

In this case, however, and still more strikingly in that of other fjords on our coasts, examination of the Admiralty charts will show that stream-erosion alone is not sufficient. Killary Harbour happens to deepen fairly uniformly from Aasleagh to the open water; but its depth at its mouth is twenty-two fathoms, while off Mweelrea and Salruck it is still ten fathoms. The cutting action of the river cannot be responsible for excavating a groove of this depth, a great part of which lies below the level of low water.

But if the land were uplifted, the bottom of the inlet would become a portion of the ordinary valley-floor. The river would reach the sea between Inishbofin and Inishturk, and would be able, above this point, to deepen its valley until a level slightly below low water was attained. The history of Killary Harbour is no doubt embodied in the reverse of this suggested process. The land at no distant time stood distinctly higher above the sea, and the Erriff River, from Aasleagh down, had a fairly rapid fall. The great groove, in fact, severing Mweelrea from Benchoona, is an ordinary river-valley, cut by a stream that started in pre-glacial times. The floor of this valley gradually approached the sea-level, the level of no ex-

cavating action; and at last, in the ordinary course, the sea would have crept up a little at the valley-mouth. But then came the subsidence that has affected our islands so profoundly, accompanied, doubtless, by considerable warping of the old continental floor. Levels were everywhere disturbed, and disturbed irregularly; but the main result on the west coast of Europe, from the "rias" of Spain* to the peaked isles of northern Norway, was the admission of the sea into the intricacies of the denuded land. The lower ten miles of the Erriff valley became converted into Killary Harbour, while the deep clefts in the braes of Bergen admitted the Atlantic for more than a hundred miles.

It has often, however, been pointed out that, for the production of a true fjord, with its sides free from débris and going down like cliffs into the water, another agent must be introduced. There was a time when fjords were believed to have been excavated, to great depths below sea-level, by the eroding power of glacier-ice. The physical difficulties opposed to this view proved to be considerable; and dwellers in countries where glaciers are still common have long set their faces against it. But the presence of a glacier in any valley prevents it from becoming choked by detritus from the mountain-walls. The excavating action, which was begun before the ice spread down all the hollows of the country, may still be carried on by the subglacial streams; while the ice all the time moulds the valley-walls as it moves forward, and converts each projection in the floor into a characteristic *roche moutonnée*. Hence, when subsidence occurs, the sea may for some time be banked out of the valley by the presence of the ice. As the glacier shrinks, the sea follows it up the well-preserved groove, in which the only deposits are those of the spreading terminal moraine. For a long period the fjord may thus retain its most typical form; but at length a delta may spread down from its head, sandbanks may be swept in by the sea, and ordinary taluses may descend upon it and mar the smoothness of its walls.

Killary Harbour has reached this later stage; but there is no doubt as to the original prevalence of glacial conditions in the district. The whole lower ground of Letterfrack, Tullycross, and Salruck, is ice-worn and mammillated, and the peat forms as yet only a thin covering across the *roches moutonnées*. The larger of these stand out bare and uncorroded; and the striæ on their surfaces, whether the rock is slate or quartzite or conglomerate, are still marvellously fresh. Probably, as the glaciers withdrew, banks of mud and gravel, washed out from the terminal moraines, covered this lowland in the place of confluent ice; and the coating that was thus formed helped to preserve the bed-rock from denudation. But here, as elsewhere in our islands, we are led to regard the retreat of the glaciers as a very recent matter. The abundant cirques in the high levels of the mountains, though not so bare and stern as those of Snowdon, still preserve their outlines, much as when the last ice melted from their floors. One of the latest phases of this old-world highland may have been the most magnificent from a scenic point of view, when the contrasts of crag and snow in Connaught rivalled the glories of Norway or Alaska.

Even now, are these western mountains of necessity doomed to obliteration? Though the breaches of Mweelrea lie open to the Atlantic storms, and though the grass creeps across the summits, helped by the soft summer rain, may we not read in the long and complex history a tale of regeneration, of vitality rather than decay?

* See KNOWLEDGE, Vol. XX., p. 210. (September, 1897.)

SELF-IRRIGATION IN PLANTS.—II.

By the Rev. ALEX. S. WILSON, M.A., B.Sc.

THE arrangements possessed by plants for collecting and conveying rain to their roots, described in the previous article, derive their value from the circumstance that leaves have but little absorbent power. If greatly parched they will no doubt take up water, but the whole structure of an ordinary leaf is that of an organ highly adapted to the function of eliminating water. Not only are the superficial cells provided with a cuticle through which water can only penetrate very slowly, but moistening causes the stomata to close, cutting off access to the cells in the interior of the leaf.

Nevertheless, a limited amount of absorption by leaves does occur, and in exceptional cases groups of thin-walled leaf-cells exist which are specialized for this very end. It is principally in species growing under peculiarly adverse conditions, such as shore and desert plants, that marked absorption through leaves occurs. The experiments of Garreau show that the cuticle of many leaves is absolutely impervious to water. This is so especially in old and fully developed leaves. Young leaves, on the other hand, in which cuticularization has not gone far, absorb to a greater or less degree. Washing with soap and water removes wax and increases the absorbent power of leaves. Over the midrib and veins the cuticle is thinner than on other parts of the leaf, and water can penetrate more easily. By far the greater proportion of the absorption takes place, however, at the base of the petiole—in the axil of the leaf, in fact.

Some of the best established instances of imbibition by leaves occur among plants such as the fuller's teasel, which are provided with leaf-cups. The leaves of the teasel are arranged in pairs; the broadened base of each leaf unites with that of its opposite neighbour, encircling the stem and forming a receptacle in which a quantity of water collects. That this source supplements the supply furnished by the roots is shown by the fact that cut specimens retain their freshness as long as the leaf-cups are supplied. Leaf-cups of this description are seen in Silphium—one of the gentians—and in a number of other plants. Many epiphytic Bromelias, Tillandsias, and others of the pineapple family retain considerable quantities of water in their expanded leaf-bases, and of this a portion is absorbed by means of certain thin-walled cells.

FIG. 1.—Leaf-cups of Teasel.

These examples have an important bearing on the case of the chickweed, now to be considered. The rapidity with which this plant spreads over garden soil must be attributed in large measure to its very complete system of self-irrigation. The sheathing bases of each pair of leaves on the chickweed form a kind of leaf-cup where the rain collects. Particles of dust and earth are also washed down into the leaf-axils. Hairs on the margins of the petioles

help to retain the water, so that the quantity detained at the nodes is greater than one would expect; indeed, these little reservoirs, relatively to the size of the plant, have, perhaps, quite as large capacity as the leaf-cups of the teasel. The leaf-stalks are channelled, but instead of grooves the chickweed stem has a line of hairs placed on one side, which conducts the overflow from one leaf-cup down to the next, so that after a shower all the leaf-cups are replenished. These hairs on the stem are deflexed, easily wetted, and are evidently arranged to act as rain conductors.

Each hair consists of several cells which still retain their protoplasm. In a dry condition the walls of the basal cell present a striated appearance, and this has led Kerner to assign to the hairs an absorbent function. But this explanation is unsatisfactory. In the first place, precisely similar striations appear on the leaves and stem if the plant be somewhat dry. Again, the hairs have no direct connection with the vascular system, from which they are separated by a thick cellular cortex. Cut off from the internal circulation their power of transmission must be very limited, and whatever water they absorb is quite likely to be lost again on the air becoming dry. The evidence of special adaptation is, at least, not conclusive; moreover, a circumstance overlooked by Kerner seems to render such special adaptation superfluous. From many of the leaf-axils of chickweed one or two little rootlets emerge. Even where none are visible a transverse section of the stem reveals their presence beneath the epidermis. It is a very reasonable supposition that the arrangement of conducting hairs and leaf-cups in the chickweed, by which its nodes are kept moist, is designed to promote the formation of these lateral rootlets. Gardeners, at least, when they wish to induce the formation of roots, often adopt a similar expedient. In propagating certain plants recourse is had to *marcottage*, or the application of moist earth to the base of a branch to stimulate the development of roots. Sir Joseph Hooker, in his *Himalayan Journals*, states that the roots which descend from the boughs of the banyan tree are induced to sprout by wet clay and moss tied to the branches, underneath which a little pot of water is hung. So dense is the foliage that the ground beneath the branches gets very dry and hard, the descending roots are unable to penetrate it, and the natives assist matters by conducting the roots through bamboo tubes and by breaking up and moistening the soil at the points where they enter it. At first these roots are very slender, but they soon swell and tighten from the rooting part dragging down the aërial.

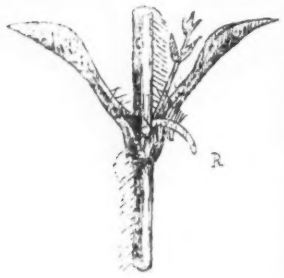

FIG. 2.—Irrigation of the Chickweed. R, Rootlet.

The water and particles of earth that accumulate in the leaf-cups of the chickweed not only conduce to the formation of roots—the conducting hairs serve to water them after they are developed. Each rootlet is most conveniently placed to catch the rain descending from the leaves; indeed, were it placed under a running tap the position of the rootlet could hardly be more favourable. On the whole, therefore, it seems much more probable that the use of the hairs is to conduct water to the roots, where it is absorbed, than that the hairs themselves are absorbent organs.

If we remove a quantity of chickweed from ground where it has been growing luxuriantly, we are often struck by the remarkable dryness and hardness of the earth. On reaching the soil its rootlets would, therefore, experience difficulty in penetrating were it not that there is an additional point of resemblance to the banyan. The water which drips frequently from the tips of the rootlets keeps the earth soft and moist just at those spots where the rootlets enter it. When they have established themselves they drag down the stem; each internode and each young shoot become practically independent; hence the rapidity with which this weed spreads.

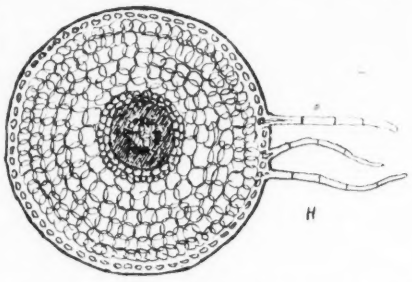

FIG. 3.—Transverse Section of Chickweed Stem. H, Hairs.

Another circumstance worthy of mention is the obvious relation between the conducting hairs and the axillary buds. Although the hairs are differently placed in successive internodes, they are always on the same side as the axillary bud below. The latter is consequently drenched from time to time by rain descending along the conducting hairs. As young leaves are to some extent capable of absorbing, the developing shoots must, therefore, participate along with the rootlets in the benefits of this system of automatic irrigation.

The special necessity for this curious arrangement in the chickweed may possibly arise from the small amount of lignified tissue possessed by the plant. Its rapid growth does not, indeed, admit of much lignification, which is a process requiring time. Not only is the vascular cylinder running up the centre of the stem of small dimensions, but the four lignified strands (dark coloured in the figure), through which the water rises from the roots, are very slender relatively to the thickness of the stem. We might almost compare the chickweed to a house where the pipe from the main is of narrow calibre, and an additional supply has to be obtained by collecting the rain from the roof into cisterns. As the tendency of cultivation is to render soil dry, this double water-supply is also advantageous, no doubt, in relation to the peculiar habitat of the plant.

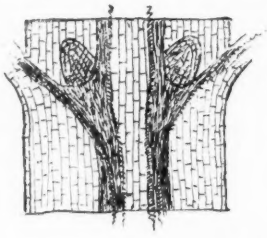

FIG. 4.—Vertical Section of Chickweed Stem, with two Rudimentary Rootlets. The Spiral Vessels show the course of the ascending Sap.

Aqueducts consisting of lines of hairs similar to those of the chickweed occur in a number of plants. The Germander speedwell has a line of hairs on both sides of its stem, and in allied species there may be three or more such lines corresponding in position exactly to the grooves by which rain is led down the stems of so many plants. Those speedwells which occur as garden weeds emit rootlets, and have the same creeping habit as the chickweed. Their delicate transparent rootlets are often exquisitely beautiful, being covered with microscopic fibrils so exceed-

ingly sensitive that they contract at once if exposed to dry air.

The spiderwort, commonly grown as a hanging plant, has sheathing leaves capable of retaining water, and emits rootlets in the same way. There are a few hairs at each node, but they are not continued down the stem. The spiderwort has, however, a special provision against desiccation; the upper layer of the leaf consists of aqueous tissue, composed of clear prismatic cells filled with water. A piece of this plant may be carried about in one's pocket for more than a week without quite losing its freshness. Leaf-cups, however, occur chiefly on plants growing in places where there is little risk of desiccation; hence it is supposed by some that in aërial absorption the object is not so much water as to obtain a supply of nitrogen. Nor is it at all improbable that the rootlets of the chickweed take up nitrogenous compounds and other substances dissolved in the rain-water which accumulates in its leaf-cups. But this question must be reserved for future consideration.

CELÈBES: A PROBLEM IN DISTRIBUTION.

By R. LYDEKKER, B.A., F.R.S.

PROBABLY at least nine out of every ten of the readers of KNOWLEDGE who do me the honour to peruse the present article, would pronounce the name of the island mentioned in the heading with the second syllable short—Celĕbes; and if it were an English name they would be right in so doing. But the Malays have a habit of accenting the middle syllable of three-syllabled words, and we thus have Saráwak, Basílan, Celébes, etc. In this respect Malay names are the exact opposite of South American, in which the accent falls on the third syllable, as in Panamá, Bogotá, and Ecuadór. Doubtless it is a small matter, but it is well to be correct even in the pronunciation of names.

Having put matters right in this respect, the next point is to inform my readers why Celebes has been selected as the subject of an article at all; and why Borneo, Sumatra, or Java would not have done just as well. To render this point clear I must refer briefly to the geographical position of Celebes and the neighbouring islands. Borneo, Sumatra, and Java, as my readers are no doubt well aware, are the three largest of the Malayan islands lying nearest to the Malay Peninsula; and although they possess many peculiar animals—notably the orang, which is confined to Borneo and Sumatra—yet their fauna as a whole is very similar to that of the Malay mainland, and thus intimately connected with that of India. Accordingly, naturalists are pretty well agreed in including these islands in what is called the Oriental region of zoological distribution, of which the Philippine Islands likewise form a part.

Now, Celebes lies due east of Borneo, from which it is separated by the Macassar Strait, and also nearly midway between the Philippines on the north and the small islands of Lombok, Sumbawa, and Flores on the south; these three latter islands forming the continuation of the line of Sumatra and Java, which evidently indicate an old peninsula. Eastward of Celebes lie the Moluccas (or Spice Islands) on the north, and Ceram (which forms the lowest member of the same group) in the south; both these being nearly midway between Celebes and Papua, or New Guinea. And when we reach the latter country we are practically in Australia, the animals being quite unlike those of the typical Malayan islands and the other countries of the Oriental region; we have, for instance, in New Guinea, tree kangaroos, cuscuses, flying phalangers, bandicoots, echidnas or spiny anteaters, cassowaries, cockatoos, birds of paradise, and bower birds, all of which are essentially Australian types, although some, like the birds of paradise, attain their maximum development in New Guinea itself. The little island of Ceram has also a fauna of an Australian type, including, among other forms, a cassowary. Accordingly, all naturalists are agreed that Australia, New Guinea, Ceram, and the other Moluccas, together with the Aru and some of the other small islands in the neighbourhood, form one great zoological province, which may be called the Australasian. But the problem has been in which region to place Celebes, whose fauna is in some respects intermediate between that of the Australasian and Oriental regions. By Dr. A. R. Wallace, the great authority on the geographical distribution of animals, it was at first classed with the former, although subsequently given a doubtful position; and his views have been followed by most later writers. Quite recently, however, Mr. W. L. Sclater, the Director of the South African Museum, has come to the conclusion that it should be included in the Oriental region.

A glance at the map will show that Celebes is an island of very peculiar and unusual shape. It consists of an irregular central region, from which are given off four still more irregular peninsulas, of which the one running in the direction of the Moluccas is considerably the largest. Its general outline is more like that frequently assumed by an amœba than anything else, and it is quite clear from this remarkable shape that the island is situated in a subsiding area, and once formed a portion of a much larger land mass. From the peculiarity of its animals it is evident that Celebes has existed as an island since an epoch comparatively remote; and the question naturally arises whether its last connection was with Borneo and the other Malayan islands, or with Ceram and New Guinea. In a question of this nature the depths of the surrounding seas have, of course, a most important bearing. There is reason to believe that recent investigations will do much towards clearing up this question, but as they have not yet been published they cannot be further referred to on this occasion.

Putting, then, the evidence of soundings on one side, we may endeavour to find out how much light the animals of Celebes are capable of throwing on the problem.

Those of my readers who have any acquaintance with the subject of the geographical distribution of animals, are doubtless aware that no marsupials at all are found to the westward of Celebes, and that to the eastward of that island monkeys are quite unknown, while hoofed animals are represented only by a deer in Timor and a second in the Moluccas, and likewise by a semi-wild pig in Ceram and another in New Guinea. In fact, the quadrupeds of the Australasian region, apart from bats and these exceptions, consist exclusively of egg-laying mammals, marsupials, and various peculiar kinds of rats and mice; while, as already said, their birds include cassowaries, cockatoos, birds of paradise, bower-birds, and a host of other kinds more or less completely unknown in the regions to the westward.

But, unfortunately, there is another element in the problem which introduces a further complexity. The Malays, as we know, are bold and clever sailors, fond of voyaging from island to island in these summer seas. And they are also wonderful adepts in taming animals of various kinds. Many of these they carry about with them in their voyages—some probably for food and others as pets. When they land on a strange island some of these animals may occasionally escape, or possibly may be turned loose intentionally. Now there is a very considerable

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probability that the wild pigs of Ceram and New Guinea have been thus introduced; and if this be the case, the fauna of the Australasian region is made more absolutely distinct from that of the Oriental province. The deer of the Moluccas and Timor present a case of greater difficulty; but, as the Moluccas cannot well be separated from the Australasian region, they would seem, in these islands at least, to have been introduced, and, if so, the same will hold good with certain smaller mammals of an Oriental type, such as civets.

We are now in a position to consider how the animals of Celebes compare with those of the neighbouring islands. Now, the only mammals of a purely Australian type found in that island are two species of cuscuses—sleepy creatures, with beautifully soft fur, often very brilliantly coloured, and showing great individual or sexual variation in the markings. They are near relatives of the so-called opossums (phalangers) of Australia, and are purely arboreal creatures, passing the day comfortably coiled up in slumber, and feeding at night. If these creatures were of a type which might be regarded as near to that from which the other marsupials of Australia might have sprung, they might be considered as survivors from the migration of marsupials which probably took place at a remote epoch from Asia to Australia. But they are not so, and it is therefore clear that this hypothesis will not account for their presence in the island. As they are so completely arboreal in their habits, they are, however, just the kind of creatures which we might naturally expect to be wafted from one island to another on floating timber; and it is far from improbable that it is to this mode of transport they owe their presence in Celebes.

All the other mammals are of an Oriental type, although several of them are quite unlike their relatives on the mainland and other islands. Among them one of the most remarkable is the babirussa, a curious little pig, in which the tusks of both jaws in the males attain a most extraordinary development, the lower ones curving straight upwards, while the upper ones grow right through the skull to curve backwards in a bold sweep towards the eyes. Although nothing definitely is known as to the origin of this strange animal, yet it is evidently a highly specialized offshoot from the ancestral pigs of Asia. Equally peculiar is the tiny little black buffalo, or anoa, which is not much larger than a good-sized ram, and has upright horns quite unlike those of the ordinary Asiatic buffalo. In the island of Mindoro, near the centre of the Philippine group, there is, however, a considerably larger buffalo, known as the tamarau, which serves to connect the anoa with the ordinary Asiatic species. More important still is the occurrence in the Tertiary deposits of Northern India of several species of buffaloes intimately related to the anoa. Clearly, then, this animal has originated from an Oriental stock, and the occurrence of an allied species in the Philippines tends to show that these islands were connected at no very remote epoch with Celebes. Now the Philippines themselves, as shown by their deer, have intimate relationships with Borneo, and thus with the mainland.

The deer reported to occur in the island is a variety of the rusa of Java, and apparently identical with the form found in the Moluccas. It is generally considered to have been introduced, but as Celebes shows so many signs of affinity with the more western Malayan islands in its animals, this does not appear by any means certain. Anyway, the Moluccan race may well have been exported from Celebes by the Malays.

The next most noteworthy animals in the mammalian fauna of the island are two species of monkeys, both remarkable for their black colour. The first of these is the short-tailed black baboon, a species representing a genus by itself, and with relationships to the true baboons of Africa and Arabia. Such relationship, from a geographical point of view, might seem difficult to account for, and to those who neglect the animals of a past epoch it would appear well-nigh inexplicable. But it happens that extinct baboons occur in India; and as they doubtless also existed in other parts of the Oriental region, there is no difficulty in accounting for the origin of the Celebesian representative of the group. The other species—the Moor macaque—belongs to a widely spread Oriental genus.

But the most curious of all the mammals of the island is a species of tarsier—a small creature with enormous goggle eyes, slender lanky limbs, and toes terminating in suckers—distantly related to the lemurs. Now, these tarsiers are strictly limited to the islands of Sumatra, Borneo, Java, Celebes, and Mindanao, together with some of the neighbouring islets; and are totally unknown to the eastward of the Molucca Sea. Although, being arboreal animals, it may be argued that, like the cuscuses of Celebes, they have been carried about by floating timber, it seems in the highest degree unlikely they should have reached all the islands with an Oriental type of fauna, and avoided all those where the true Australian type comes in. Moreover, they are very delicate animals, exceedingly difficult to keep alive in captivity, and there is accordingly a strong probability that they are native to the islands where they occur. Like so many of its other animals, the tarsier of Celebes is black—as, indeed, are the species from the other islands.

So far, then, as their mammals are concerned, it seems probable that at no very distant epoch Celebes, Borneo, and the Philippines formed one land area; while Borneo itself was connected with the mainland, probably by way of Sumatra, the orang and some other species being common to these two islands and unknown elsewhere. It is further probable that Celebes, and most likely a portion of the Philippines, became isolated before Borneo ceased to be connected with Sumatra—or at all events with the mainland. But the south-western portion of the Philippine group, namely, the island of Palawan, shows evidence of a closer connection with Borneo than with the rest of the archipelago to which it belongs. On the other hand, the mountains of Luzon, in the Northern Philippines, contain a remarkable group of rats, some of which show affinity to those inhabiting Australia; and it therefore seems highly likely that the Philippines mark a portion of the line by which Asia was probably in communication at a still earlier epoch with New Guinea and Australia. Still, there are some difficulties in this view of the case, because the more primitive types of marsupials now found in Australia are at present unknown in New Guinea. Possibly, however, some still remain to be discovered in the unexplored mountains of that country; while, as the exploration of the Luzon Mountains by Mr. John Whitehead has yielded such wonderful zoological results,* there is a hope that when the mountains of the other islands have been as carefully worked we may find a few marsupials still surviving. Should such a fortunate "find" turn up, we should have almost conclusive evidence that the ancestors of the present fauna of Australia travelled from Asia by way of the eastern archipelago.

There are many other points connected with the present distribution of animal life in this wonderful region, and their bearing on the former relations of the various islands to one another, to which the limits of this article forbid

* The mammals from these mountains have been worked out by Mr. O. Thomas, of the British Museum.

reference. A word may, however, be said in reference to Timor, which, as already mentioned, forms the eastern extremity of the line of the Sunda Islands—that is to say, the line including Sumatra, Java, and Flores, which is evidently a broken-up peninsula. By most writers that portion of the chain lying to the eastward of Java and Bali has been assigned to the Australasian region, and it has consequently been assumed that the deer found in Timor must have been introduced by man. Timor and Flores also contain several other mammals common to the Oriental region, notably a monkey, a civet, a porcupine, and a palm civet; and although it is quite possible that they may have been introduced by the Malays (as some of them appear to have been into the Moluccas), the absence of any typically Australasian mammals except a cuscus (whose presence may be accounted for in the same way as in Celebes) is, to say the least, very remarkable. Moreover, the birds of Timor show at least as many Oriental as Australasian features, and it accordingly seems more consonant with the known facts to regard the whole chain of the Sunda Islands, which are geographically one, as having formed a part of the old Asiatic continent.

British Ornithological Notes.

Conducted by Harry F. Witherby, f.z.s., m.b.o.u.

Pied Flycatcher in Caithness.—A pair of these birds took up their quarters in our garden about the middle of May. The male appeared first and remained four days. Two days after it disappeared the female put in an appearance, but did not remain. Messrs. J. A. Harvie-Brown and T. E. Buckley, in their "Fauna of Sutherland and Caithness," say: "The first known to have occurred in the county was obtained by ourselves in a very wild burn some eight or nine miles from Brora on the 27th of May, 1872." Now this appears to be a mistake, because in May, 1867, I shot and preserved a pair, male and female, which they notice on the next page from Mr. Osborne's MS. On May 10th, 1881, I again saw several specimens, one of which I preserved.—James Sutherland, Wick.

Red-backed Shrike in Caithness.—A pair of these birds, obtained in the neighbourhood of Wick on the 20th of May, has been sent to me for preservation. In the "Fauna of Sutherland and Caithness" it is stated: "One is recorded as being in Dunrobin Museum, but there is no history attached to it." A young bird of this species is in the Duke of Portland's collection at Welbeck Abbey, but there is no precise date or locality given beyond the general statement that all the birds in the collection were shot on the Duke's property in Caithness. A specimen of this bird is mentioned by the late Dr. Sinclair, of Wick, as having been killed in the county.—James Sutherland, Wick.

Protection of Birds in Scotland. — The question of the protection of birds by law has again been under consideration. In Scotland, as was foretold in the appendix to the last annual report of the Society for the Protection of Birds, an excellent proposal by Lord Balfour of Burleigh is now before the various County Councils of that country. The suggestion is to divide Scotland into two districts, northern and southern, the dividing line being the southern boundary of Argyll and Perth (Bute and Arran to be included in the northern division), and for the County Councils in each of these areas to seek identical Orders under the Wild Birds Protection Acts, so that all concerned can readily make themselves acquainted with the provisions of the Orders in force for the protection of birds and their eggs.

A list of thirty-two birds is given, which shows what species should receive protection in *both* districts, and also lists of the *additional* birds which should be protected—fifteen species in the northern and eleven in the southern district.

Bird lovers will be glad to note that some species are recommended for protection all the year round. Cannot some of our ornithological friends help to draw up a similar scheme for the grouping of counties in England?

The Home Secretary would no doubt welcome such a scheme, were it presented in a practical form.—M. L. Lemon, Hon. Sec. Society for the Protection of Birds, July 15th, 1898.

The Long-tailed Duck in Killala Bay and the Estuary of the Moy. By Robert Warren. (*Irish Naturalist*, May, 1898, pp. 121-124.)—We have here detailed accounts of the various occurrences of this duck (uncommon in Ireland) in the districts named.

Mr. Robert Patterson records in the *Irish Naturalist* for July, 1898, p. 170, the following rarities which he believes have not been before recorded:—

Rough-legged Buzzard.—A male was shot at Portaffery, Co. Down, on November 8th, 1895.

Grey Phalarope.—One was picked up at Ballymoney, Co. Antrim, in October, 1896.

Hawfinch.—A male was shot at Hillsborough, Co. Down, on December 30th, 1897.

The Whinchat, Ortolan Bunting, and Pied Flycatcher in Shetland (*Annals of Scottish Natural History*, July, 1898, p. 178).—Mr. W. E. Clarke here records the capture of the above species by Mr. Thomas Henderson, jun., in Shetland, during a remarkable visitation of migrants. All three species are new to the avifauna of Shetland.

Marsh Harrier in Dumfriesshire (*Annals of Scottish Natural History*, July, 1898, p. 182).—Mr. R. Service records that a male Marsh Harrier (a very rare species in Scotland) was shot in Carmichael early in May, 1898.

Ring Dove nesting in the City of Edinburgh (*Annals of Scottish Natural History*, July, 1898, p. 183).—While so much attention has lately been directed to the nesting of Wood Pigeons in London, it is interesting to hear from Mr. Arch. Craig that a pair of these birds is nesting in Edinburgh.

On Birds observed in the Island of Tiree. By Peter Anderson (*Annals of Scottish Natural History*, July, 1898, pp. 153-161).—This is a list of one hundred and twenty-eight species of birds observed on Tiree during the author's twelve years' residence in the island.

On the nesting of the Pintail (*Dafila acuta*) *in the Forth Area.* By William Evans, f.r.s.e. (*Annals of Scottish Natural History*, July, 1898, pp. 162-164).—Up to the time of the publication of this article there were only two or three reliable records of the nesting of the Pintail in the British Islands. It is, therefore, very satisfactory and of the greatest interest to learn from Mr. Evans, in this careful and incontrovertible report, that several pairs (perhaps six or seven) of Pintails have nested this year on Loch Leven, in Kinross-shire. Mr. Evans carefully identified the birds which rose from the nests he found, and even went so far as to hatch two of the eggs in an incubator.

Woodchat Shrike in Sussex (*Zoologist*, June, 1898, p. 267).—Mr. G. W. Bradshaw records the occurrence of a male Woodchat near St. Leonards-on-Sea on May 1st, 1898.

Hawfinch in Midlothian (*Annals of Scottish Natural History*, April, 1898, p. 114).—Mr. W. Eagle Clarke reports that on March 9th an adult female Hawfinch was picked up dead at Arniston. In August, 1894, a young Hawfinch was captured at the same spot, and Mr. Clarke points out that these two records are of great interest, since the Hawfinch was formerly only regarded as a rare winter visitor to Scotland. Although large and conspicuous, the Hawfinch is of a shy nature and retiring habits, and a little further search may result in adding the species to the list of birds which are resident in Scotland.

Melodious Warblers in South-East Devon (*Zoologist*, June, 1898, p. 265).—The Rev. Murray R. Mathew describes how he watched and listened to quite a number of Warblers, which he identified as *Hypolais polyglotta*, in a wooded undercliff at Ware, near Lyme Regis, in the beginning of May this year. Clear views of the birds were obtained at the distance of a yard. The Melodious Warbler very closely resembles the Icterine Warbler (*see* note, Knowledge, November, 1897, p. 257).

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at 1, Eliot Place, Blackheath, Kent.*

"INSECT MINERS."

By FRED. ENOCK, F.L.S., F.E.S., etc.

INSECT miners, though somewhat rare in the "Black Country," are only too plentiful in the London district. Being no respecters of persons, they invade even Royal gardens, where we find whole families of them working together in the most orderly, systematic, and determined manner. I might truthfully say that thousands of these insects are brought into London every morning by ship, road, or rail.

Let us take one of the favourite flowers of the Londoner —the white Marguerite—a flower to be seen in every street from Belgravia to Whitechapel. When the first crop of flowers begins to fade, and the leaves are thus exposed to view, those of us who have eyes for such things can at once detect a peculiar appearance about the leaves. Many of them are disfigured with variously shaped yellow-looking markings. Some people imagine the plant to be dying, and hasten its end by consigning it to the dustbin. Others wonder what is the matter with their Marguerite, and frequently set to work and wash the plant—which is a very good plan, as it invigorates the growth, causing new shoots to form as well as buds, but it does not prevent the miners going on with their work, and even extending operations to the fresh growth.

FIG. 1.—Golden Marguerite affected with "the Maggot."

Some few years ago I was privileged to conduct some lectures on economic entomology for the Essex County Council, and was much encouraged to find some of my audience bringing various specimens of insect and plant life which had attracted their attention. The beautiful yellow Marguerite was brought suffering from "the black fly," which the grower could not get rid of from many of his old stock plants; and no sooner had he started a fresh stock for the coming season than this "fly" made its appearance, and, in many instances, completely ruined the plants for sale.

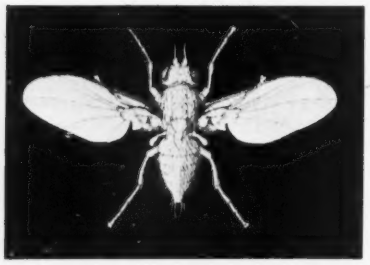

FIG. 2.—The Marguerite Fly (*Phytomyza affinis*). (× 12 Diameters.)

Fig. 1 is from a photograph of one of these afflicted yellow Marguerites. The plant has scarcely a sound spray of leaves—nearly all being "eaten up" by the "fly," or rather maggot of this injurious insect. I bred a large number of *P. affinis* (Fig. 2) from the golden Marguerite. It is a minute, two-winged fly about one-twelfth of an inch in length, slatey black, with black bristles on head and thorax; the head is pale yellowish brown, legs dark, with yellowish tips and *haltères*. It has a decided objection to being watched, and some patience is required to overcome the "now on the upper, now on the lower" surface of the leaf; then, just when you think you have it settled, it hops right away out of sight, and you must wait for its return or seek another.

Much patience and some gentleness of movement will be required before you succeed in observing its method of oviposition. After selecting a spot on the upper surface it protrudes the rasped point of its telescopic ovipositor, which it forces through the upper cuticle; and then between that and the lower (Fig. 4) it inserts an egg of an oval form. Withdrawing its ovipositor it rapidly reverses its position, and protruding its tongue proceeds to hermetically seal up with saliva the aperture made (Fig. 5). Numbers of eggs are so laid in each leaf, great care being taken to carefully seal up each one. The next day minute blisters appear over the egg, which hatches on or about the fourth or fifth day into a tiny legless maggot, our first representative of a "miner" (Fig. 6). Nature has taught it that it must work for its living, and being provided with the necessary muscular power it immediately commences to use its excavating tools, which are in its mouth (centre of Fig. 6). With these tools it obtains nutriment, and at the same time levers its way between the cuticles, the "working" gradually though slowly increasing in width and length. In the yellow Marguerite it is straighter than is the case in the broader leaves of the white Marguerite, where it not unfrequently follows the serrated margin of the leaf for a distance of an inch or more. At other times the insect works a somewhat tortuous course across the leaf, and occasionally, after making a narrow mine, it seems to hit upon an exceedingly nice-flavoured piece of leaf, around and about which it lingers and makes a well-formed harbour (Fig. 7). The course of the mining larva is marked by the minute pellets of frass which are plainly visible through the bleached upper cuticle (Figs. 7 and 8). In less than a fortnight the miner has finished its excavation; its work, so far as mining is concerned, is done, and its tools are no longer required. At the head of the larva (left hand of Fig. 6) will be noticed two short prominences. These appear to be used as

FIG. 3.—Leaves of Golden Marguerite, showing Larvæ of *Phytomyza affinis*. (Natural size.)

FIG. 4.—Marguerite Fly ovipositing in Leaf. (× 12 Diameters.)

holdfasts, and are driven through the upper cuticle, and the pupal stage is reached (Fig. 8), though sometimes the larva quits the leaf and falls to the ground to undergo this change. The fly is soon matured, and, bursting through the dry larval skin, it emerges to continue its species; and under the artificial though favourable conditions of plants kept and propagated under glass, numbers of broods emerge in the course of each year.

Like all other insect "pests," it has its parasites—minute and busy Hymenoptera, quite black in colour, which hover about the infected leaves (Fig. 6), ever ready to attack the larva and insert one of their own eggs in the body of the miner (*see* Fig. 8).

When the parasitic maggot has reached its full growth (and of course destroyed the maggot of the Marguerite fly) it passes on to the pupa stage within the dried skin of

Fig. 5.—Marguerite Fly sealing up the Egg. (×12 Diameters.)

its host, which is now bleached to a light colour. The enclosed *black* pupa of the parasite is now a conspicuous object to even an ordinary observer, and care should be taken not to destroy these *black* coloured ones. If growers of Marguerites and other flowers would just note a few of these apparently slight differences, a great deal of good might be done towards increasing these parasites, which are the natural enemies of the injurious maggots.

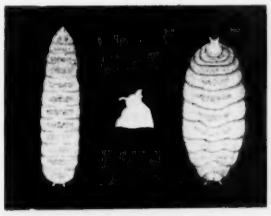

Fig. 6.—Larva, Head of ditto, and Pupa of Marguerite Fly. (×12 Diameters.)

Another favourite flower with everyone, especially Londoners, is the chrysanthemum; and yet how very few growers, amateur as well as professional, know the fly, *Trypeta chrysanthemi*, which is the cause of the mining maggot that excavates between the cuticles, eating all the life away, until the leaves begin to twist up and fall, leaving the plant totally unfit for exhibition. The finger-and-thumb treatment is the quickest way of destroying the miner, which can easily be felt, if not seen; but the perfect insect is generally overlooked altogether. I own that it is not a particularly easy one to capture, but it is worth the attempt, as one female is capable of laying a great number of eggs, distributed over one or two dozen plants, and can easily blight all chances of prize-taking at an exhibition. I have noticed the fly all through the summer months, for there are several broods. Before the heat of the day is the best time for observing it, and it is worth observation, as, apart from the advantage of knowing enemies from friends, the fly is an exceedingly interesting one to watch. It is smaller than the ordinary house fly, and of an ochreous colour; its eyes of the most brilliant shining green, which at certain angles appear golden red; its wings are ample, with several diffused spots on them. In graceful movements of the wings few flies can equal this one. The wings are gently raised and lowered together, then suddenly one is twisted at a peculiar angle, whilst the insect itself walks round in a circle. Sometimes the wings are allowed to drag along the leaves, after the manner of a strutting turkeycock; then they are suddenly

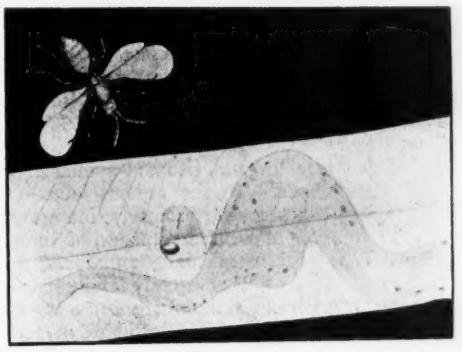

Fig. 7.—Egg (Cuticle raised), Part of Mine, and Parasite of Marguerite Fly. (×12 Diameters.)

raised high up together, and the fly seems to take fright and run under cover, only to return and indulge in other strange movements. Should one of the opposite sex approach, these movements are increased, and quite defy description. Those chrysanthemum growers who really wish to capture these flies should use a small net, made of

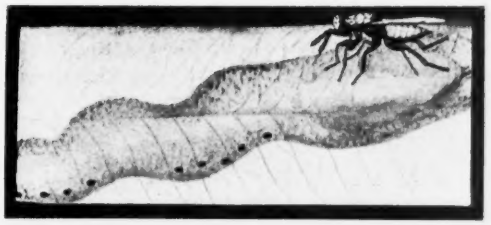

Fig. 8.—Continuation of Mine and Pupa of Marguerite Fly, in which Parasite is ovipositing. (×12 Diameters.)

fine book muslin, fixed on a ring of cane four inches in diameter, the net of the jelly bag from about eight to ten inches in length. With a little practice many flies can be caught without injury to the plants. Observation of the mines will soon reveal the parasite peculiar to this fly.

(*To be continued.*)

Notices of Books.

Electro-Physiology. Vol. II. By W. Biedermann, Professor of Physiology in Jena. Translated by Frances A. Welby. (London: Macmillan & Co.) 17s. net. We have here a good translation of the second volume of a standard work. The range of subjects treated is the best evidence of the progress which has been made in this branch of science since the inception of the subject by Galvani's experiment in 1790, when, working at Bologna, he observed the curious convulsive movements in the muscles of a recently killed frog when touched at different points by iron and copper which were in contact. The volume before us, beginning with the electro-motive action in vegetable cells, goes on to deal, in separate chapters, with such subjects as the structure and organization of nerve, the conductivity and excitability of nerve, the electrical excitation of nerve, the electro-motive action in

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nerve, electrical fishes, and the electro-motive action in the eye. While the book is full of interesting experiments, such examples as that with the uninjured leaf of *Dionæa*, or, as it is more familiarly called, "Venus's fly trap"—where, electrodes being applied to the opposite ends of such a leaf, and a galvanometer included in the circuit, a regular current flows from that end of the leaf nearest to the stalk to the other—will perhaps appeal most to the ordinary reader. The wonderful physiological properties of certain fishes have been known and dreaded from the earliest times. Francesco Redi showed in 1666 that this mysterious power was, at all events in the electric ray, associated with special organs, situated symmetrically on both sides of the head. In the present volume we are given an exhaustive account, profusely illustrated and extending to upwards of a hundred pages, of the present state of our knowledge of all these animals. For the results of these and many other equally fascinating studies we must refer to the book itself, which in the style of its production is quite up to the high standard of excellence one always associates with the names of its publishers.

William Moon, LL.D., and his Work for the Blind. By John Rutherford, M.A., B.D. (London: Hodder & Stoughton.) 5s. Of the many systems of embossed characters by means of which the blind are enabled to read, that invented by Dr. Moon is undoubtedly the simplest and most easily acquired. Not only is it suitable for educating children who are blind, but it is also admirably adapted for older people who have lost their sight. In fact, it is in this respect that the system elaborated by Dr. Moon stands pre-eminent. More than half of the total number of persons who are unable to see are over fifty years of age, and in a large number of these cases the fingers have become hardened by manual labour, and the sense of touch has lost much of its acuteness. These facts make it impossible for such persons to master the more elaborate systems which were previously in vogue; and when it is remembered that often the loss of sight is attended by a more or less complete nervous collapse, it will be seen that embossed alphabets based upon systems of phonography are altogether unsuitable because of the degree of concentration required to master them. Dr. Moon's alphabet consists of only nine characters placed in various positions. Thus, the character ∧ stands for A, K, V, X, in the varied positions of ∧ < V >. Dr. Moon himself became totally blind at the age of twenty-one, and from that time devoted his life to the work of lightening the darkness of his fellow-sufferers. His perfected alphabet was the crowning point of a series of less successful experiments, and was soon applied to the production of books for the blind in a variety of foreign languages, including even Chinese. But the education of the blind was, in the hands of Dr. Moon, carried much further than mere reading, for by means of an embossed atlas of geographical maps and drawings in relief showing the constellations, the solar system, phases of the moon, eclipses, tides, etc., he gave evidence alike of his perseverance and ingenuity, and provided the blind with sources of instruction and enjoyment. After so useful a career we can partly understand the spirit which prompted Dr. Moon when he said: "God gave me blindness as a talent to be used for His glory. Without blindness I should never have been able to see the needs of the blind."

Ethnological Studies among the North-West Central Queensland Aborigines. By Walter E. Roth, B.A., etc. (Brisbane: E. Gregory. London: Queensland Agent-General's Office. 1897.) It is satisfactory to be given this further evidence of systematic inquiry into the language, customs, and habits of Australian aboriginals. The spread of civilization in these new countries inevitably results in the elimination of the native races, and it becomes a positive duty of the invaders to gather and record accurate information concerning the superstitions, beliefs, and ceremonial rights of the races they displace. This duty is fully recognized in the United States, where the Bureau of Ethnology is continuously employed in collecting and publishing similar facts about the North American Indians. We are, therefore, glad to see this officially published contribution to the ethnology of the natives of Queensland. Of course, the first essential in conducting such an inquiry is the confidence and trust of the aborigines in the expert observer. In this respect Mr. Roth had unrivalled opportunities, and he seems to have made the most of them. The book is filled with details of interest to anthropologists, but a particular value is to be attached to the chapter on the expression of ideas by manual signs. These are not only fully described in the text, but are also illustrated by a profusion of figures on several plates.

Text-Book of Physical Chemistry. By Clarence L. Speyers. (New York: D. van Nostrand Company. London: E. & F. N. Spon.) 7s. 6d. Physical chemistry, though a subject of distinctly modern growth, has become a very important branch of science, scarcely a day passing without some new development of it. But though it is a comparatively new subject, there are certain fundamental ideas in physical chemistry which will not suffer change, and these Mr. Speyers has put into his book, though some theories have been included which will almost certainly have to be modified. The book is intended for senior students, and should prove useful in those advanced chemistry courses where it can be fairly assumed that an efficient mathematical knowledge is part of the student's intellectual stock-in-trade. The non-existence of working hypotheses connecting light energy and so-called chemical energy, has decided the author to omit any reference to light relations and crystallography. The historical development of the subject has, we think wisely, been disregarded whenever the clear presentment of the subject has been thereby aided. The excellent series of problems scattered throughout the volume will, if conscientiously worked, prove of particular value to the student.

SHORT NOTICES.

The Arrangement of Atoms in Space. By J. H. Van't Hoff. Second Edition. (Longmans.) 6s. 6d. Organic compounds of similar formulæ do not always possess the same properties. For example, tartaric acid exists in different forms, yet the formula of each modification contains exactly the same number of atoms. To explain this and similar cases, a new branch of organic chemistry has arisen, called "stereo-isomerism." The author says, in the introduction to the book before us, that "the facts compel us to explain the difference between isomeric molecules possessing the same structural formulæ by the different arrangement of their atoms in space"—a conception of atoms which is essentially a continuation of Kekule's law of tetravalent carbon. A preface is added by Prof. Wislicenus, who, by the way, states that the opposition to the theory is directed against special applications of the principle to explain particular facts, and not against the general principle itself. A new section has been added by Alfred Werner on nitrogen compounds, and the whole is admirably presented in English by the translator—Arnold Eiloart.

The Year-Book of British Columbia. By R. E. Gosnell. (British Columbia Government Agency.) We have in this handy volume a multitude of facts respecting the material resources, and the historical, political, and sociological character of British Columbia, the whole forming a *vade mecum* of information concerning the province, so compiled as to anticipate all references of a practical nature. At the present time many people are anxious to obtain exact knowledge respecting mining in the great North-West, and it will, perhaps, be welcome news to those who contemplate enterprises of this kind when we say that here are to be found mining statistics up to date, mining laws—including the Yukon mining regulations—agriculture, trade

and finance, outfitting and expenses, and so on, all well authenticated in every particular—explicit details, definite conditions, actual results.

Life Histories of American Insects. By Clarence Moores Weed. (Macmillan.) Illustrated. 6s. net. Consists of a series of able sketches of a few of the principal American insects, profusely illustrated with first-rate diagrams and plates. To entomologists this book will, we think, form a useful acquisition, and general readers who occasionally indulge in light science may hope for both information and amusement by a perusal of these bright and stimulating pages.

Nature Studies in Elementary Schools. By Mrs. Lucy Wilson, PH.D. (Macmillan.) Illustrated. 3s. 6d. Mrs. Wilson has designed a book which aims at imparting to teachers a method of conveying instruction in a way that must prove both amusing and interesting to all grades of children. The book is divided into months, and for each month full particulars are set down as to the subjects of instruction; the curriculum including weather, plants, animals, fruits and stones, varying according to the period of the year at which the lessons are supposed to be given.

BOOKS RECEIVED.

Practical Organic Chemistry. By Samuel Rideal, D.SC. Second Edition. (H. K. Lewis.) 2s. 6d.

The Birds of Montreal. By Ernest D. Wintle. (John Wheldon & Co.)

A Text-Book of Zoology. By H. G. Wells and A. M. Davies. (Clive.) Illustrated. 6s. 6d.

Financial Sketches. By Hélène Gingold and Dudley Hardy. (Columbus Printing, Publishing, and Advertising Co.) Illustrated. 1s.

Stepping Stones to Literature. By Sarah Louise Arnold and Chas. B. Gilbert. (Silver, Burdett, & Co.)

Directory (revised to June, 1898), with Regulations for establishing and conducting Science and Art Schools and Classes. (Spottiswoode.) 6d.

On Sea Beaches and Sandbanks. By Vaughan Cornish, M.SC. (Reprinted from the *Geographical Journal.*)

Archives of the Röntgen Ray. Edited by W. S. Hedley, M.D., and Sydney Rowland, M.A. Vol. II., No. 4. (The Rebman Publishing Co.) Illustrated. 4s. net.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

SUNSPOTS.

To the Editors of KNOWLEDGE.

SIRS,—In a letter of Mr. Shackleton's in the May issue of KNOWLEDGE (p. 113), he quotes the late R. A. Proctor as confirming a theory of refraction lately advanced by Mr. East, and illustrated by him by the familiar old experiment of a bowl of water with a penny at the bottom of it; and in the concluding paragraph of his letter he seems to consider that this theory is therefore a settled matter, which ought to have found its way into recent books treating on the subject as an accepted view of one of the phenomena of sunspots.

I cannot help thinking that Mr. Shackleton attributes rather too much importance to the few words said by Proctor in the passage alluded to in "Old and New Astronomy." He is not discussing the visibility of the umbra in a foreshortened spot; he does not mention it or allude to it in any way, here or anywhere else, except by a few words in a short note, after he had made his drawing for a totally different purpose. He is describing the manner in which he imagines a sunspot to be formed, and he gives a sketch of what he conceives would be the section of a spot according to this view. It must have struck him that, if this section was a true one, it would be impossible to see the umbra at all when a spot was foreshortened; and he then suggested the idea of refraction as a means of bringing the umbra into view. Surely this theory requires a little more discussion and explanation than a few words added casually in a note. It is hardly one to be accepted as if it was the most obvious thing in the world, which only had to be stated to be received without a shadow of doubt as to its truth.

I do not therefore think that Proctor intended to lay down this theory for general acceptance upon his authority, as one thoroughly examined and deliberately adopted by him. However that may be, it is clear that this theory is only needed if the section of a spot drawn by Proctor is a true one. *Is* the umbra something at the bottom of a cavity, which requires, in a foreshortened spot, to be brought into view by refraction like the penny in the bowl of water? I maintain that it is not, but that, on the contrary, the umbra is more or less on a level with the outer

FIG. 1.—Ideal Section of a Sunspot.

edge of the penumbra. I did not adopt this view hastily, or merely as a way out of a difficulty, but only after having bestowed a good deal of attention to the matter. It was only after having spent some time on every available day for some months, carefully observing and drawing every spot that occurred, that the conclusion forced itself slowly and irresistibly upon me, in opposition to what I had before imagined to be the generally accepted view—that the umbra, instead of being a hole at the bottom of a

FIG. 2.—Changes in the Appearance of a Symmetrical Spot due to foreshortening.

depression, was in reality on a general level with the top of it. My idea is that at the edge of the penumbra there is at first a considerable depression, which continues for a certain distance towards the centre, and that the surface then rises gradually into a cone, the open top of which is the umbra.

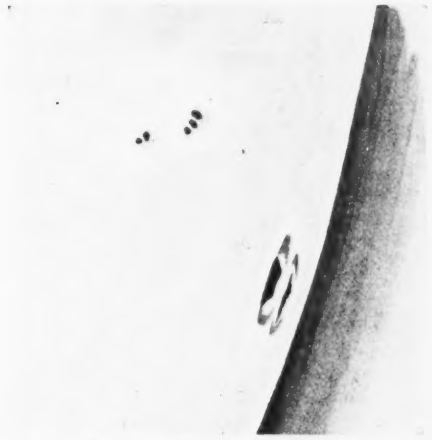

FIG. 3.—A Group of Sunspots on the First Day after passing the East Limb. May 6th.

I take it to be impossible to draw any true section of a sunspot, and the outline I have drawn is only intended to show my meaning in the roughest and most general manner. If, then, the umbra is, as I imagine, the open summit of a cone, its circumference would form a ring with a dark centre (I am taking the case, of course, of an ordinary symmetrical spot), while the edge of the penumbra

would form an outer ring; and as long as any portion of the inside of one ring was visible, the same amount would be visible of the other. It follows, then, from this view that there is no necessity to fish up the umbra by refraction from the bottom of a spot. As to its possibility, I am in no way competent to form an opinion; but as regards the illustration given in support of the theory, I fancy that a pair of bellows brought to bear upon the surface of the water in the bowl would obliterate the image of the penny at the bottom of it, just in the same way as a very slight ripple coming upon the surface of calm water instantly renders all objects invisible at the bottom; and, considering what the eruptive force must be which produces a sunspot, and the violence of the movements which must be going on among the gases and vapours within its area, the conditions do not seem favourable to the transmission of an image by refraction.

There is, however, another point which has always seemed to me to require some explanation, viz., the rapidity with which a spot opens out when still but a short distance from the limb—more observable in some cases than in others. I have often been surprised to find that a spot which was little more than a mere line on one day had opened out within twenty-four hours to a degree that I did

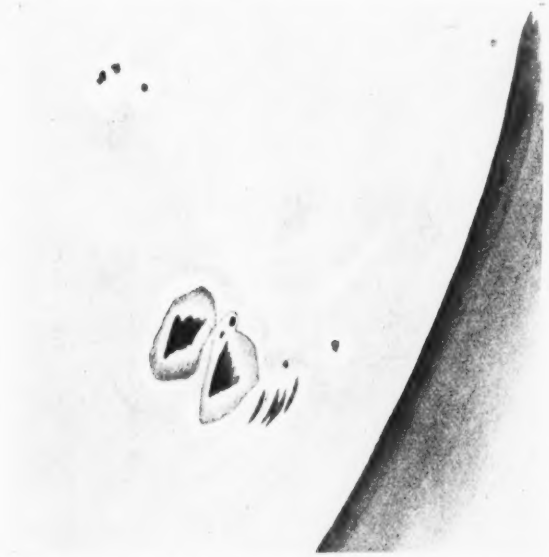

FIG. 4.—A Group of Sunspots on the Second Day after passing the East Limb. May 7th.

not know how to account for. It has sometimes occurred to me whether refraction could have anything to do with it; not refraction, however, within the spot itself, but that of the sun's atmosphere, as we are, in this case, looking along the surface of the sun for an immense distance, and, consequently, through the greatest possible amount of his atmosphere. The two drawings are very rough copies of drawings of spots showing the extent to which a spot opened out from one day to another after its first appearance on the east limb. J. H. JENKINSON.

Ocklye, Crowborough, May 23rd, 1898.

[The context of the passage from Proctor's "Old and New Astronomy," quoted by Mr. Shackleton, fully supports Mr. Jenkinson's suggestion that Proctor's reference to refraction in sunspots was a mere casual incident in his argument. The point he is really discussing is whether sunspots have their origin from below or above, and he supports the former view with all his usual insight and masterly grasp of principles. On the other hand, as he works out his idea, he shows how slight was his personal observational experience. The sharp well-defined circular outline is far more characteristic of the western than of the eastern border of spots, and decay in spot groups, in the great majority of instances, begins to the eastward and works to the front. To my own mind a sunspot appears a region of upheaval—an upheaval which results in a breach in the glowing shell we call the photosphere, and a smaller breach in the less brilliant shell below it which forms the penumbræ of spots. I regard the photosphere in the neighbourhood of a spot, the penumbra, and the umbra, as probably all convex to the general level of the sun's surface; the amount of convexity probably varies immensely in different spots.—E. WALTER MAUNDER.]

THE ECLIPSE THEORY OF VARIABLE STARS.

To the Editors of KNOWLEDGE.

SIRS,—The title of Colonel Markwick's paper seems to me somewhat misleading. The theory referred to does not embrace all variable stars, but a class only.

My object in writing is, however, a different one. Your able contributor seems to assume that the surface-brightness of stars is uniform. In the case of the sun we know that this is not true. Near the edge the brightness is not more than one-seventh of what it is near the centre. This fact seems to be satisfactorily explained by the assumption of a solar atmosphere, which there are other grounds for believing. Assuming that Algol is similarly constituted and that the satellite (B) was quite dark, still the light would not be constant from the time that the whole of the satellite got in front of the bright star (A) until it began to move off again. The minimum would occur when the satellite occupied the most central position in front of the bright star. If the eclipse was central it would occur when the centres of both stars were in the line of sight.

I think it very probable that in these cases the eclipsing body is not quite dark. If the satellite of Sirius crossed the face of the bright star, the phenomena would probably be undistinguishable from those caused by the passage of a dark satellite. One thing, at all events, seems certain. We know of no instance in which the eclipse is total; but on the assumption of a dark companion, it would be natural to expect that its surface would be smaller than that of the bright star, and that therefore the eclipse would not in any event be total.

Further, the eclipsing body may not be a star, but a dense cloud of meteors. In many cases we are driven to the conclusion that, if it be a star, its density is very small in spite of its opacity and comparatively low temperature. The sun's motion in space must ultimately affect these eclipse stars, though our periods of observation may not hitherto have been long enough to detect the change. In almost every instance the eclipse must be becoming either greater or less. In the former case the duration of the change will become greater and the difference between the maximum and minimum will become greater also. In the latter case the eclipse will become less and less until it disappears altogether. Of course, where the eclipse is now increasing it will ultimately decrease again after becoming central; and no doubt eclipses will hereafter appear in the case of stars whose light is at present constant. Spica Virginis is very possibly such a star. Either it has been an eclipse variable in the past, or else it will become so in the future. W. H. S. MONCK.

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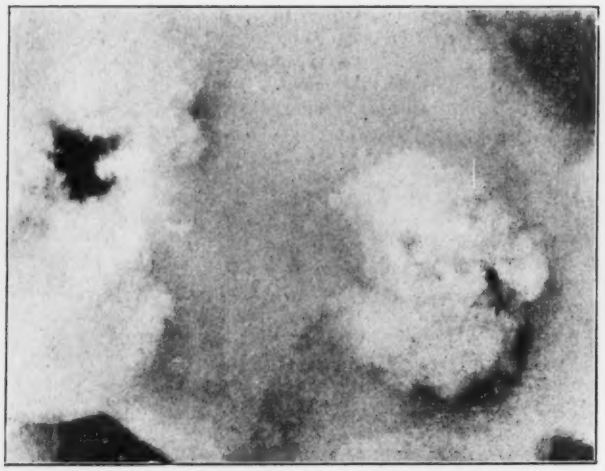
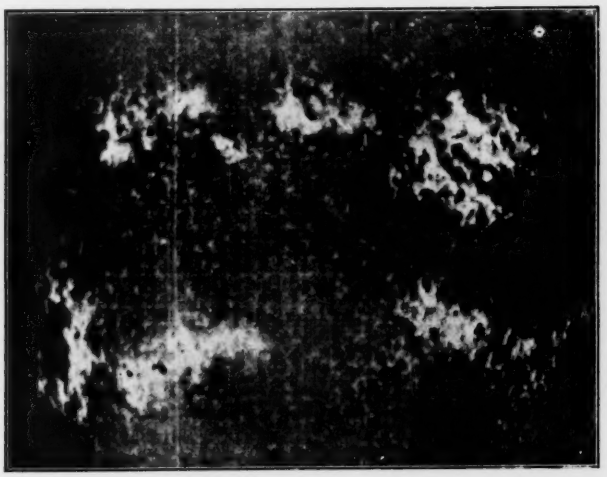
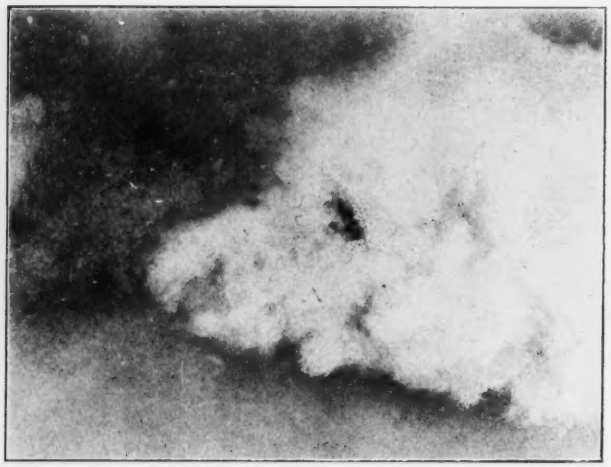
ARTIFICIAL AND NATURAL FACULÆ.



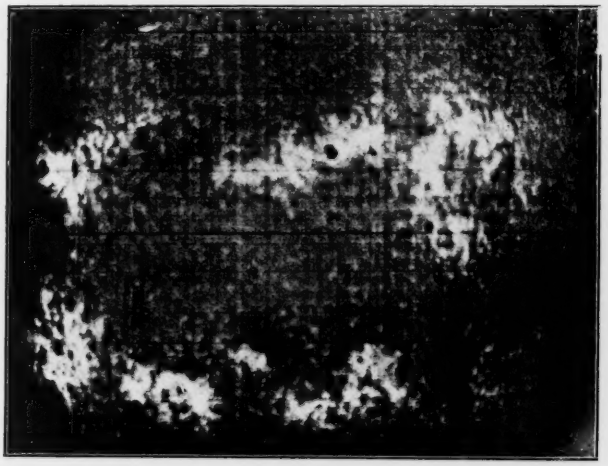
A.—Artificial Faculæ with part of Overhanging Pulp removed, showing an Ordinary Spot.



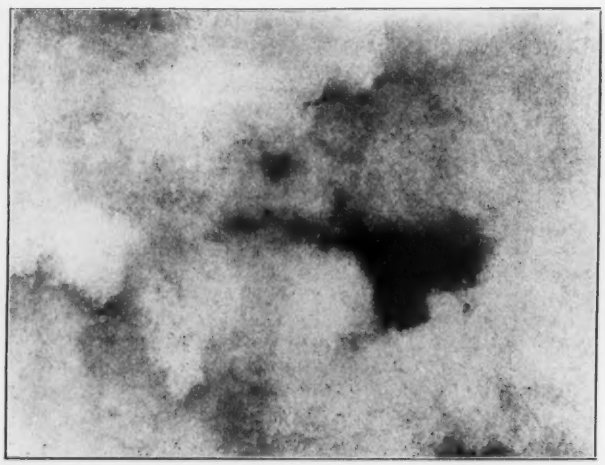
D.—Faculæ taken with Prof. Hale's Spectro-heliograph, at Kenwood Observatory, July 11th, 1893, at 10 a.m.



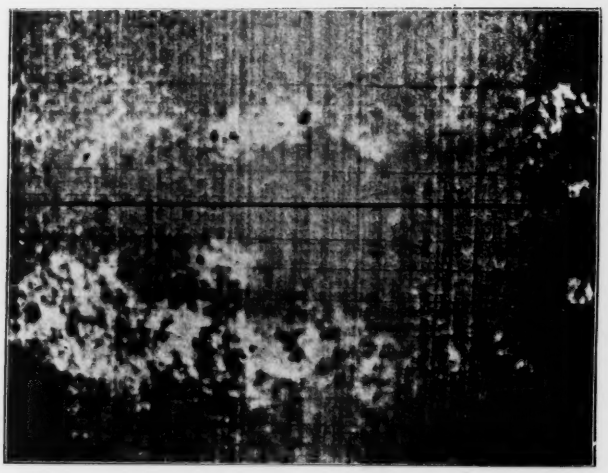
B.—Large Patch of Artificial Faculæ.



E.—Faculæ taken on July 13th, 1893, at 8 a.m.



C.—The same as B, but with part uncovered, showing Spot below.



F.—Faculæ taken August 7th, 1893, at noon.

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To the Editors of Knowledge.

Sirs,—Colonel Markwick, in his interesting paper on variable stars, is at pains to reconcile his flat curves at minimum with the real ones. This would be easily explained by supposing the nearer star *not* to pass centrally over the other, but so that its upper or lower edge coincided or overlapped its primary. Then the slightest movement to left or right would reduce the occulting area. It would be interesting to calculate curves for bodies of equal size, but only partially occulting one another.

The whole subject suggests in the future a wonderful widening of the harvest of fact. Harold Whichello.

HOOKED PROCESS ON BEES' MANDIBLES.

To the Editors of Knowledge.

Sirs,—In Knowledge, October, 1895, appeared a letter and sketch of a hooked process on the mandible of the bee (*Apis melifica*). In the succeeding number, Mr. T. A. Cowan wrote asserting that they were not hooks, but hairs, and pointing out that they were correctly figured in his book on the honey bee. This is rather ancient history, but my excuse for referring to the subject after so long an interval is that immediately after the publication of my letter I was laid on my back by a long illness, which for a long time after recovery prevented the use of my microscope. I have now taken up the subject again. I have asked the opinion of several gentlemen of authority as entomologists—among others, Mr. Fred. Enock, whose most interesting papers are now appearing in your columns—and they endorse my view that the objects under discussion are hooks and not hairs. I have carefully examined Mr. Cowan's book, and I find that they are *not figured* there, neither is any reference made to them, inclining me and others to think that Mr. Cowan has mistaken the hairs that fringe the mandible for the hooks that are placed on the buttress of chitine that bridges the concavity of the mandible. They are so specialized that Mr. Enock says that they must have some very practical use (I suggested in my letter that they might be used in clustering), but at present that use is a mystery. Sir John Lubbock was kind enough to inform me that he had not previously noticed them, and had no idea of their utility; so that perhaps I may, though with the humbleness of the tyro, be permitted to claim that I was the first to call attention to these interesting microscopic objects, all the more remarkable for having remained so long unnoticed on an insect so closely studied as the hive bee. Walter Wesché.

ARTIFICIAL FACULÆ.

By the Rev. Arthur East.

An article appeared in the December and April Numbers of Knowledge giving an account of some experiments made with paper pulp in order to illustrate a theory of the formation of sunspots. It is proposed in the present article to apply the same method to faculæ.

It had long been almost necessarily supposed that the faculæ, as the bright rifts and ridges seen on the edge of the sun are called, extended really over the whole spot-zone surface of the sun; but it was reserved for Prof. Hale actually to photograph them with his spectro-heliograph in localities extending across the whole disc, where, telescopically, faculæ are invisible.

A delightful account of this triumph of photography is given in Sir Robert Ball's "Story of the Sun"; and by the kindness of Prof. Hale, now at the Yerkes Observatory, I am enabled to illustrate this article with three of the remarkable pictures of the solar surface taken with the spectro-heliograph of the Kenwood Observatory in Chicago.

What will immediately strike anyone accustomed only to the telescopic appearance of spots is the *cloudy* aspect of the solar surface, and the absence of the clearly cut, crisp outline of the spots to which he is accustomed, but an aspect which the artificial spots (as may be seen) very faithfully reproduce; this cloudy appearance is not due, I believe, to any imperfection of the photograph, but to the faculæ being so much more evident. We seem to see here cloudy masses of vast extent lifted high above the surface of the photosphere, and bright because lifted beyond the "fog or smoke stratum" of the sun (an expression of Prof. Hastings, endorsed by Prof. Young, and most consoling to the Londoner).

There is one most instructive feature in the spectro-heliographs here given, viz., that there are several *pairs* of spots visible—not circular, but elliptical, and with the appearance of being, as it were, *back to back*, as if the spots were openings on opposite flanks of a vast tumulus; and looking as though, were the overlying mass to be removed, a single orifice would be disclosed underneath.

And it also very clearly appears from these pairs of spots that the penumbra being widest on the eastern edge of a spot which is passing off the limb, is no argument against the Wilsonian theory of depression, but may be due to the spot being crateriform, or an *elevated* depression, as suggested in a former article.

Now, this lifting of the photosphere into faculæ is precisely what we frequently get with the artificial spots, as Fig. B may help to show. When the heat is applied, often, instead of any spot appearing, flocculent masses rise, and are, moreover, remarkably permanent—a characteristic feature of faculæ according to Prof. Young: the heated water meanwhile escapes at the sides of the upheaved mass; but, if the mass be removed, an ordinary spot is found below (Figs. A and C).

There is probably no doubt now remaining that faculæ are very closely related to spots; spots are apparently always accompanied by faculæ, although faculæ often occur without spots, but the particular nature of the relationship is not known.

The behaviour of artificial faculæ—as Figs. A, B, and C will show—suggests that the faculæ are really masses of condensed vapour which *overhang and conceal* the spots, and that in many cases, if not in most, if the faculæ are dispersed an ordinary spot will be disclosed. Thus Fig. A shows two patches of faculæ, but one is uncovered to show the spot below; Fig. B, again, is a larger mass of artificial faculæ. After this photograph was taken, the overhanging mass was gently removed in one place, and Fig. C was taken, to show the ordinary spot below. The relationship between faculæ and spots would thus be exceedingly close, the suggestion being that wherever faculæ are seen there also are corresponding spots below, from which the vapours forming the faculæ are being, or have been, ejected; that in certain conditions of the solar atmosphere, as in our terrestrial atmosphere, these condensed vapours are reabsorbed or dispersed, and the *open* spot (if it may be so termed) disclosed; but that at other times the vapours are not so dispersed, and continue to overhang the spot from which they come, entirely concealing it, and appearing as part of the photosphere, except to the eye of the spectro-heliograph.

If this be so, and faculæ in all cases have spots below them, it would explain very simply the extreme rapidity with which large spots at times appear; they are, in fact, *uncovered*. The telescope shows, perhaps, a disc entirely

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plain and free from spots, ignoring faculæ which it is unable to show. Meanwhile the spots may be there concealed by faculæ, until some violent disturbance scatters the faculæ and the spot is suddenly revealed.

Faculæ would be, according to the view here expressed, identical with the photosphere, being only solar clouds at a higher level, but distinct from the prominences, although closely associated with them.

[Kindly allow me to say that, when writing the article on sunspots which appeared in the April Number of KNOWLEDGE, I was quite unaware of the passage from the late R. A. Proctor's "Old and New Astronomy," and of his ideal section of a sunspot, quoted by Mr. Wm. Shackleton, or I should certainly have referred to it; but I am grateful to Mr. Shackleton for drawing attention to the passage.—ARTHUR EAST.]

THE OBJECTIVE PRISM, THE FLASH, AND THE REVERSING LAYER.

By E. WALTER MAUNDER, F.R.A.S.

WITHIN the last few years a special form of spectroscope has come largely into public notice. Readers of KNOWLEDGE need only refer back to the number for March, 1897, and they will there find, opposite page 78, six beautiful photographs of stellar spectra. These, as Mr. Fowler has fully explained in the article which accompanies the plate, were taken with what is now usually called a "prismatic camera"—that is to say, a photographic telescope before the object glass of which a prism or train of prisms had been placed. In effect this formed the posterior half of a giant spectroscope, the anterior—the slit and collimator—being absent. The slit was not needed, as the star is itself but a point of light, as minute as the narrowest slit; the collimator was not necessary, as the rays of light from the star were already parallel when they reached the prism. The prism and view-telescope, therefore, were all that in this case were required.

The spectrum of a star with such an instrument is a very narrow line; a broken line whose vacant spaces represent the dark Fraunhofer lines that we see in the solar spectrum. Such a broken line would be too narrow for useful work, but by causing the telescope to move at a slightly different rate from that of the star the latter can be made to "trail," and thus the spectrum may be broadened out to any required extent. As will be seen by reference to the plate in question, a star spectrum so obtained looks exactly like the spectrum given by an ordinary slit spectroscope.

But this instrument is quite suitable for other kinds of work, and its recent revival as an eclipse instrument, by Sir Norman Lockyer, has shown it to be, taken all round, our most powerful instrument for eclipse research.

But the appearance of the spectra of an eclipse with a prismatic camera is quite different from the spectra to which we are ordinarily accustomed. If we look through a prism at the young moon when she first sets her thinnest silver crescent in the western sky, we shall see a spectrum like that which an ordinary slit spectroscope will give us, but with one great difference: the dark lines would no longer be straight, but would be semicircles. All the chief lines so familiar to us in the ordinary Fraunhofer spectrum would be there, but instead of each being an image in negative of a straight narrow slit, each is an image in negative of the slender arch of the moon itself. Exactly in the same way, if we watch through a prism the coming on of an eclipse of the sun, we shall see, shortly before totality, when the encroaching dark disc of the moon has reduced what is left of the sun to a thin crescent-like arc, a spectrum with the Fraunhofer lines all circular arcs; images in negative, that is to say, of the little strip of sun still uneclipsed, instead of the straight lines with which the ordinary slit spectroscope has made us familiar. In other words, we shall see spectra precisely like the first and last of the splendid series of photographs which Mr. Evershed gave us in the June Number.

So far the matter is very plain, but just before second contact the state of affairs becomes much more complicated. It may appear a very obvious truism to say that, at any moment during the eclipse, the spectrum which we obtain is the spectrum of that bright object which is exposed to our view at that moment, but it is a fact which has to be very clearly kept in mind. In a slit spectroscope, the slit is the source of light, for no other light is admitted to the spectroscope except that which comes through the slit. The slit may not be fully illuminated, and, in such a case, it is only the lighted part of the slit which is the source of our spectrum. But here, with a prismatic camera directed towards an eclipse in progress, the source of light is the whole of the phenomena—sun, chromosphere, prominences, and corona—that at the moment of observation remain uncovered by the dark body of the moon.

The accompanying diagram (Fig. 1) may serve to show just what it is which forms our source of light at the instant before second contact. Let the arc C A B D represent the dark approaching limb of the moon. The arc A K B represents the limb of the sun, and, as we see, only a very narrow segment of sunlight remains still disclosed. Beyond the sun's limb, however, there is a gaseous envelope of which the chromosphere forms a part. For the sake of distinctness I have supposed this envelope to consist of two strata, an upper and a lower, and we may consider the former as representing the chromosphere, the latter as representing the "flash."

What is the appearance of the spectrum at this moment? The small arc of sunlight still remaining gives us, of course, a continuous spectrum, and it will be seen that this continuous spectrum must narrow very fast as the actual moment of totality comes on. This narrowing strip of continuous spectrum is of course crossed by the Fraunhofer lines, each of which is of the same general shape as the little arc of sunlight. But above and below this arc of sunlight we find the dark limb of the moon bordered only by the gaseous envelope. At the point of the cusps, and a little beyond, we have both strata, but the lower becomes narrower and narrower, and terminates at C and D. The upper stratum can be traced further still, until it, too, is cut off by the lunar limb at E and F.

These arcs, then, A C, C E, and B D, D F, being arcs simply of glowing gas, give us bright-line spectra. The elements contained in each region will each give its own spectrum of bright lines, and these bright lines will each supply an image of the region over which that particular element is found. Above and below the continuous spectrum, therefore, with its arched Fraunhofer lines, we find a bright-line spectrum of tapering horns of light of different lengths, and we see at once that the length of any arc is an index of the height above the sun to which that particular bright line can be traced.*

As the fateful instant approaches, the continuous spectrum narrows faster and faster; the bright horns above and

* It does not, however, follow that the gas giving rise to the line extends right from the sun's surface up to this height. It may simply exist as a thin shell at the height thus determined. The different effects in the two cases are not considered here.

below multiply and extend; and just at the last moment before totality is accomplished the continuous spectrum is invaded by a number of dark longitudinal lines, resembling the "dust lines" in an ordinary slit spectroscope. The edge of the moon is of course somewhat rugged, and here and there a mountain peak or range will project right across the thread of sunlight which remains, and interrupt the continuous spectrum at that point. But the effect is not quite that of an ordinary "dust line," for if the mountain, as at G, cuts out the sunlight, it does not cut out the gaseous envelope above. This is free, therefore, to yield its own bright-line spectrum, and consequently we see our "dust line" sparkling out here and there into stars of coloured light. H is an instance where a lunar mountain hides the lower gaseous spectrum, and allows us only to see the upper. P, again, is the summit of a prominence which appears quite detached from the sun, since its base is hidden by the moon. It —a most wondrous and beautiful sight, be its explanation what it may.

The "flash" was first seen by Prof. C. A. Young in the eclipse of 1870, with a slit spectroscope attached to a telescope, the slit being placed as a tangent to the limb of the sun at the point of second contact. As he watched he saw the ordinary solar spectrum gradually fade away, and "all at once, as suddenly as a bursting rocket shoots out its stars, the whole field of view was filled with bright lines."

It will be seen, then, that this "bursting rocket" is but a stage in a process that has been going on for some time. It began at an early stage in the eclipse with the appearance at the cusps of the bright arcs of H and K, of hydrogen, and of helium, and these arcs have been multiplying right up to the moment of totality; but the final outburst is so instantaneous, and brings so great a number of lines into view, that it seems to stand out like a new phase in the phenomenon. To vary the image, hydrogen, helium, and

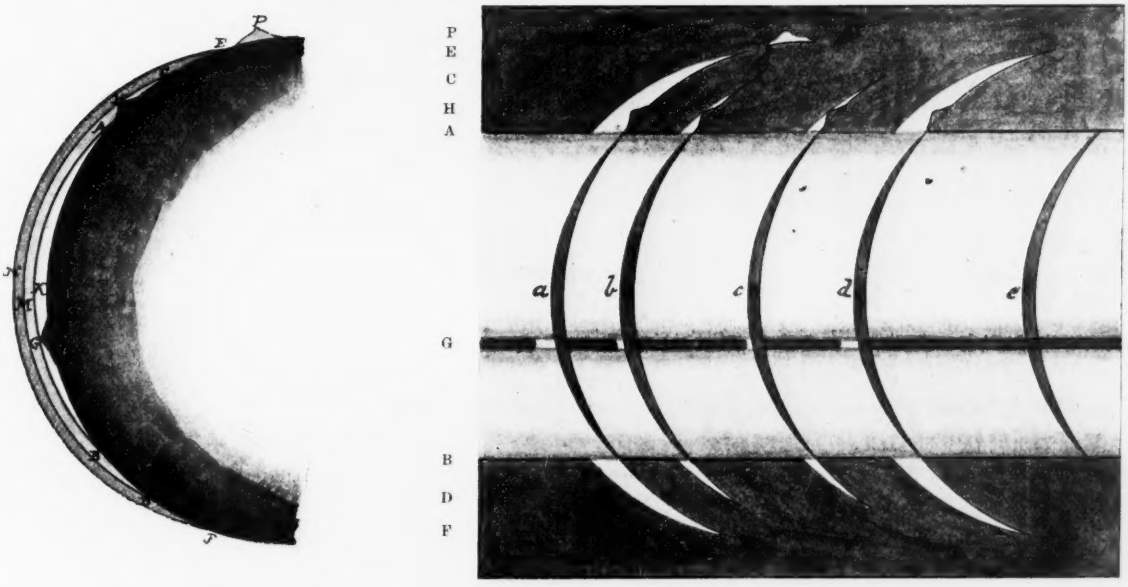


FIG. 1.—Diagram to illustrate the appearance and meaning of the Spectrum of an Eclipse, just before totality, as obtained with a Prismatic Camera. The left-hand figure represents the portion of the Sun and its Atmosphere still visible beyond the black disc of the advancing Moon; the right-hand figure the corresponding Spectrum. Lines *a* and *d* are supposed to be lines common to the Sun, the "Flash," and the Chromosphere; lines *b* and *c* are common to the Sun and the "Flash"; line *e* is seen only in the Solar Spectrum as a dark line.

therefore shows itself in the spectrum by a row of tiny coloured images of itself, shining like stars, quite detached from the remainder of the spectrum. In most prominences these will be the lines of hydrogen, helium, and the celebrated H and K lines.

The crisis is at hand; the interruptions, which I have likened to "dust lines," multiply and broaden. The intervening continuous spectra are worn down to thinnest threads, then snap and vanish, and totality has come. The tiny stars which broke up the "dust lines" flash out as a long sequence of little arcs of colour, and shine for a second, or perhaps two, ere the encroaching dark limb of the moon covers the stratum to which they belong and hides them from us. That brief, brilliant glimpse of little bright-line arcs is what is known as the "flash"—the "so-called flash," as certain over-cautious writers have termed it, in the spirit of him who censured the manners of this "so-called nineteenth century." "Flash" it is calcium might be likened to the three performers in a trio, and now, as at the descent of the conductor's baton, they have been joined by the complete chorus.

The "flash," then, represents a shallow stratum of glowing gases immediately surrounding the sun. The height to which any particular gas can be traced can be determined in three ways. First, by the length of the bright-line arc beyond the cusp which it shows at any particular moment; next, by the length of time that the moon takes to hide the stratum; third, by the extent to which a given lunar mountain may interrupt the lines of the gas at a particular moment. In one way or another we find that, roughly speaking, the "flash" corresponds to a stratum of some seven hundred miles in depth.

When Prof. Young first saw the "flash" he considered that the bright lines seen by him corresponded with the ordinary Fraunhofer lines, and he remarks that though "it would be very rash, on the strength of such a glimpse,

to assert with positiveness that these innumerable lines corresponded exactly with the dark lines of the spectrum," yet that the general appearance and grouping of the lines in the spectrum seemed perfectly familiar to him. Mr. Pye, who observed the same eclipse and also saw the "flash," says that the effect was "as if all the dark lines were converted into bright ones."

Spectroscopists have, as a rule, been content to accept the "flash" as in all probability practically a reversal of the Fraunhofer lines. Sir Norman Lockyer, whilst objecting to it, thus clearly states the ordinary view as to the "reversing layer":—

(1) We have terrestrial elements in the sun's atmosphere.

(2) They thin out in the order of vapour density, all being represented in the lower strata, since the temperature of the solar atmosphere at the lower levels is incompetent to dissociate them.

(3) In the lower strata we have especially those of higher atomic weight, all together forming a so-called "reversing layer," by which chiefly the Fraunhofer spectrum is produced. ("Chemistry of the Sun," p. 303.)

It follows that, on this view, the spectrum of the base of the solar atmosphere should most resemble the ordinary Fraunhofer spectrum (*ibid.*, p. 306). In 1873, however, Prof. Lockyer was led to take an entirely different view, and he was convinced "that the absorption took place at various levels above the photosphere." ("Recent and Coming Eclipses," p. 99.) "On this latter hypothesis, the different vapours exist normally at different distances above the photosphere, according to their powers of resisting the dissociating effects of heat." It follows that "the spectrum of the base should least resemble the Fraunhofer spectrum, because at the base we only get those molecules which can resist the highest temperatures."

The immense importance of the spectrum of the "flash" becomes at once apparent. Upon its characteristics and upon their interpretation stand or fall our whole conceptions of the chemical constitution of the sun. For the "flash" is the revelation of the spectrum of the base of the sun's atmosphere within the limits of the powers of our present instruments. A depth of seven hundred miles is an enormous one in any atmosphere, and especially in that of the sun, and must include a vast range of conditions, both of pressure and temperature; but we are at present compelled to treat it as an indivisible integer. Keeping this fact in view, that the seven hundred miles of depth of the "flash" stratum must include a great number of very distinct minor strata of which only the lowest can, on the old hypothesis, be in complete correspondence with the Fraunhofer spectrum, it is clear that we can test the rival claims by watching whether or no, as totality comes on, the ever-increasing bright horns which appear above and below the continuous spectrum are the reversals of the dark Fraunhofer arcs. On the old hypothesis, the multiplying bright lines should ever be approaching complete correspondence with the Fraunhofer spectrum up to the moment of commencement of full totality; on Lockyer's hypothesis, they should ever be diverging further from it. The conditions of observation preclude us at present from following out the process to its minutest and final detail. All we can do—and it is sufficient—is to mark in which direction the tendency lies.

It is this question of the direction of progress which is the crucial one—whether, as we get nearer the base of the solar atmosphere, the bright-line spectrum becomes more and more, or less and less, accordant with the Fraunhofer spectrum. It is not a question of establishing a complete and exact correspondence. That we could not expect. Nor is it a question of the relative intensities of the lines. With that question we are not yet competent to deal. It has been generally assumed (Sir Norman Lockyer asserts it nakedly*) that the relative intensity of the bright lines of the spectrum of any element in the laboratory ought to be the same as that of those same lines when dark in the Fraunhofer spectrum. Dr. Johnstone Stoney has recently reminded us how wholly unwarranted this assumption is; for if, as he puts it, we observe the spectrum of some source of white light through a sodium flame, and therefore see the D lines dark in a continuous spectrum, and then increase the brilliance of the sodium flame, we diminish the intensity of those dark lines.

Dr. Stoney also points out that a difference of intensity between the bright-line and the dark-line spectrum may be due to the gas being present in but very small quantities. Thus the D_3 line of helium is very brilliant as a bright line in the chromosphere, but is normally absent as a dark line from the spectrum of the disc. We cannot tell certainly whether this is due to the helium being so bright as to emit as much light as it absorbs from the sun, or whether it is so tenuous as practically to absorb nothing when we look at the sun through it, and only reveals itself at the limb in consequence of the vastly greater depth we look through; or a combination of the two factors may supply the complete explanation. For myself, believing as I do that any true solar atmosphere must be limited to a very few miles above the photosphere, and that chromosphere and prominences, however magnificent in appearance, are of the last degree of tenuity, I am disposed to put much stress upon the second suggestion. The phenomena of comets' tails might remind us how brilliant and far reaching a body may be without any real substance. Indeed, the corona itself is a case in point. We look down upon the sun day by day through millions of miles of depth of its strange, complicated structure, and are not able to recognize the faintest sign of its presence.

The "flash" past, the next stage of the phenomenon is one in which the prismatic camera still asserts its pre-eminent usefulness. The corona, prominences, and chromosphere, so far as these still lie outside the dark disc of the moon, are now our source of light. The two latter give us a bright-line spectrum only. The corona gives us a bright-line spectrum plus a faint continuous one. We have, then, still a number of bright arcs of different lengths in the spectrum, and of different shapes; for there is no prominence, there is no elevation of the chromosphere, however small, that does not give its own separate spectrum. We find the counterfeit presentment of each painted over and over again in each several tint that the lines of the gases which compose it yield. One such photograph, therefore, supplies us not with one spectrum, but with many; not with one representation of the chromosphere, but many. Thus in Mr. Evershed's beautiful photographs, taken during the total phase and reproduced in the June Number, there is no point of light that is not significant, no dot or line that has not its story to tell.

I trust that I have in the foregoing paper succeeded in impressing upon my readers some of the advantages of the prismatic camera. A further advantage is that by its extreme simplicity it is most economical of light. It is not, indeed, theoretically a suitable instrument for the determination of wave-lengths. Practically, so many of the lines seen in an eclipse being thoroughly well known,

* "The line least intense in the photograph ought to be the least intense in Thalen's tables, and if it existed in the sun at all it ought to be the least intense among the Fraunhofer lines."—"Chemistry of the Sun," p. 231.

no great drawback attaches to it in this respect. In one point, however, it is inferior to the slit spectroscope. If the lines, say from a prominence, are broadened by increase of temperature or pressure, or distorted or displaced by

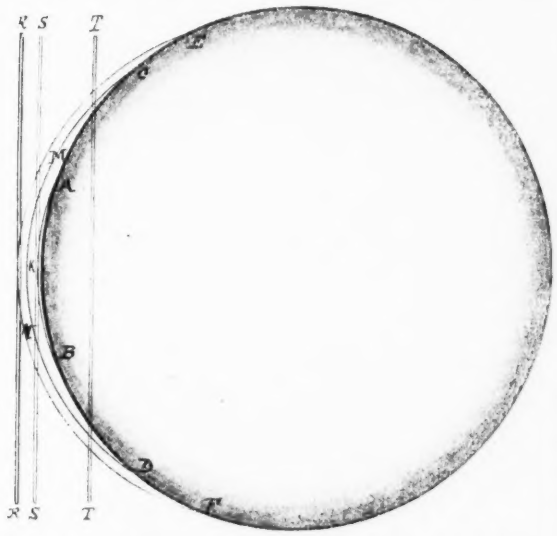


FIG. 2.—To illustrate the relative extents of the fields of view of a Slit Spectroscope and a Prismatic Camera during an Eclipse. The Prismatic Camera embraces the whole area of the phenomenon outside the dark disc of the moon. The Slit Spectroscope only the minute portion of it under the slit. For observation of the "Flash" the slit must be most exactly placed as at S S. If outside the limb of the Sun, as at R R, the "Flash" will be entirely missed; if within, as at T T, only a very small portion of it will be seen.

motion in the line of sight, such change in the shape of the line is detected in the slit spectrum: it is confused, in the spectrum with the prismatic camera, with the shape of the prominence itself. Where both forms of instrument can be used, the slit form of spectroscope should therefore not be neglected. If, however, only one form can be employed, and a choice between the two is allowed, then it would be simple folly to prefer the form of the slit spectroscope—with its limited field of view, and the risk that a minute error of adjustment may shut out from it the most important stage of the phenomena (Fig. 2)—before that of the prismatic camera, with its instructive detail, and its grasp of the eclipse in its entirety.

ALEXANDER GOODMAN MORE.

ON the 22nd of March, 1896, Alexander Goodman More, F.R.S.E., F.L.S., M.R.I.A., etc., sometime Curator of the Science and Art Museum, Dublin, passed away, aged about sixty-five years. His life had been one of much suffering and disappointment, owing to constant ill health, but was and is most fruitful to others who can reap where he has sown by patient study in the world of nature. Friends have eagerly awaited the volume of More's "Life and Letters," which is now before the public,* and proves to be a perfect treasury of interesting facts and information about birds, beasts, and butterflies—such a book as every naturalist may be glad to possess, and will find himself constantly referring to. Of the man himself this biography will tell a stranger little; a fact to be regretted, as More's personality was singularly attractive and original. Those who knew him well will not soon forget his quaint dry humour, his royal disdain of "shams" and double dealing in every form, and his determination to secure accuracy in the minutest details. His kindness and forbearance towards young naturalists were unfailing, but he never allowed them to rejoice in the triumph of a new "find" until it was absolutely verified by careful examination. More's own name will be best preserved by the book "Cybele Hibernica," which he prepared in collaboration with the late Dr. Moore, of Glasnevin Botanic Gardens (Dublin). Prof. Babington wrote "Hints" towards such a work in 1859, and one of my friend's latest efforts was to correct the proofs of a revised edition in 1893. This is now a standard work upon Irish botany, but More also wrote a goodly number of important magazine articles: "Studies on the Birds and Flowers of the Isle of Wight," "On Migration, Distribution, and Habits of Birds," etc., while keeping up correspondence with Darwin, Babington, Dr. Günther (on fishes), De Candolle, Newton, and others. Yet he was never too busy to reply to the letters of old friends, and I well remember the patience with which he studied and triumphantly verified the lesser water lily (*Nuphar intermedium*), discovered in one of his rambles beside our lake. We grew tired at last of sending him so many specimens of the plant in different stages of growth; but he persisted with his usual caution: "Verify, verify. Better take trouble and be *quite* sure." In spite of ill health, and, in later years, lameness, More was an enthusiastic collector, and his discoveries added the names of many plants to the list of British flora. I think the little *Neotinia intacta* was among his most valued "finds," but *Chara alopecuroides*, identified by Prof. Babington in 1864, was also a special treasure. From 1867 to 1887 More worked in the Dublin Museum, first as Assistant, afterwards as Curator; and the improvements made during those years must have been very great. He had pre-eminently the power of drawing out what was useful in others, and had soon an earnest band of collectors labouring for him all over Ireland. As an example of the above we note that in 1885 a White's thrush, a wood sandpiper, and a spinous shark were secured for the Museum—all rare, and the second a first specimen found in Ireland. To record here even the most interesting of Mr. More's captures would be impossible. We must refer our readers to the biography for details. He never paraded his knowledge, never boasted of his success; but as years go on one feels that his patient accuracy will make his work permanent, when the memory of more brilliant men has faded away.

C. MAUD BATTERSBY.

* Edited by C. B. Moffat, B.A. Pp. 644. Published by Hodges, Figgis, & Co., Dublin.

HOW TO PHOTOGRAPH THROUGH A FLY'S EYE.

By FRED. W. SAXBY.

IN order to perform this delicate and interesting experiment a photomicrographic apparatus will be required, and the operator should have some experience in the mounting of microscopic specimens. The object of the experiment is to obtain a multiple photograph of the subject, the images of which are to be formed by the lenticular facettes of an insect's compound eye. With few exceptions insects possess two of these eyes, one on either side of the head. The outer covering, known as the cornea, no longer functions as a single lens, but is subdivided into a multitude of extremely small

closely packed facettes, of usually hexagonal contour and convex surface. They are in some instances so numerous as to occupy nearly the whole of the head.

A section through the eye of the drone-fly, *Eristalis tenax*, gives a general idea of the structure of this organ. The cornea, hyaline in shape, is a modification of the tough exo-skeleton of the insect, and like it consists of chitine. Behind, and in the centre of each facette, is a cone of transparent gelatinous matter, with its base towards the cornea; this cone, which functions as a crystalline lens, terminates at its apex in a nervous filament. The filaments so produced converge as they proceed, and finally fuse into an optic nerve which connects them with the great nerve-ganglion or brain. Each lens with its nervous filament is isolated from those adjacent by the opaque pigment with which the intervening space is filled, so that no light passes into the eye except at that point directly under the centre of each facette. The pigment matter is variously coloured, and is the source of that sparkling appearance often seen in the eyes of living insects when viewed by reflected light.

We are at present concerned, however, with the cornea and its tiny lenses, through which we are to obtain our photograph. Each lens is a compound of two plano-convex lenses, united at their plane surfaces. The corneal mass does not follow any definite curve throughout, being considerably flatter in the middle than at the margin. In some of the larger dragon-flies parts of the eye may be found nearly flat, and on that account will serve our purpose the best. Having secured a specimen of the common dragon-fly, *Libellula depressa*, we can proceed to dissect off the cornea. First remove the head, and embed it in a cell of melted beeswax, so as to obtain a firm hold, leaving one eye exposed. Take a two-edged scalpel, and with the point of it make a series of stabs along the margin of the cornea, going all round. The entire mass, like a little dish with a quantity of pigment matter in it, can then be lifted off. Next melt the beeswax, remove the head, and float the separated cornea, with its contents uppermost, upon the still fluid wax and allow the latter to set. Pare a quill to the shape of a J pen, making the point slightly rounded and thin, and with it scrape out the contents of the eye; the cornea, being extremely tough, is not liable to injury from the point of the quill. Procure a small camelhair pencil, cut down the hairs until only an eighth of an inch long, and, having charged the stump with turpentine, proceed to twirl it about in the "dish," so as to remove the last trace of pigment. Examine under a pocket lens, and, if clean, melt out the cornea, and with a pair of fine scissors trim off the turned-up edge of the "dish," retaining only the flattest part of the bottom. Soak in turpentine until any wax that adheres is dissolved, and you have the lenses for your camera—but the disc is not flat. Select the thinnest cover-glass you can get, clean thoroughly, and place it upon the hot plate as for an ordinary balsam mount. Melt a quantity of the oldest and hardest Canada balsam obtainable, and upon the point of a needle apply a small bead of it, not larger than a pin's head, to the centre of the cover-glass. By the aid of the fine forceps and the warm air, drive off the turpentine from the piece of cornea, and then place it upon the cover-glass, concave side down, with its centre over the bead of balsam. Cut out a small disc of notepaper, rather less in diameter than the "object" you are mounting, and place it centrally over the disc of cornea. Have a three-by-one glass slip handy, support one end of it upon the hot-plate, and allow the other to press upon the object, with the disc of paper in between. Proceed to load the middle of the three-by-one slip with coins sufficient to flatten the piece of cornea. As soon as this takes place the bead of balsam under it will spread out and make its appearance round the margin of the object.

When this can be seen through the slip, remove the spirit lamp and allow the whole to cool. The under side of the flattened cornea will then be cemented to the cover-glass and the "facettes" will be simple plano-convex lenses, since their inner convexities, being embedded in the balsam, will cease to exert their optical properties to any appreciable extent. The mount, resting upon a three-by-one slip, can now be examined under the microscope. Put in a half-inch objective, and, if it has a screw collar, adjust for an "uncovered" object. Use a low power eyepiece of about three diameters and an Abbé condenser. Stop down the aperture and bring the cornea into sharp focus. By a solid cone of transmitted light an hexagonal figure will be seen forming the boundary of each facette. A number of hairs appear upon the eyes of some insects, and it is in the angles of these hexagons that the hairs have their origin. It will require some nicety of illumination, however, to disclose the "lens" in each of these divisions; the solid cone of light as usually transmitted by the condenser fails to reveal them. Remove the limiting diaphragm from the back of the condenser and insert in its place a patch-stop that will give dark-ground illumination with the objective employed, having previously stopped out half the annulus with a strip of black paper. Use the plane mirror, and, with the condenser in focus, this semi-annular beam of light will fall obliquely upon the object and the "eye-lenses" will appear in bold relief (Fig. 1).

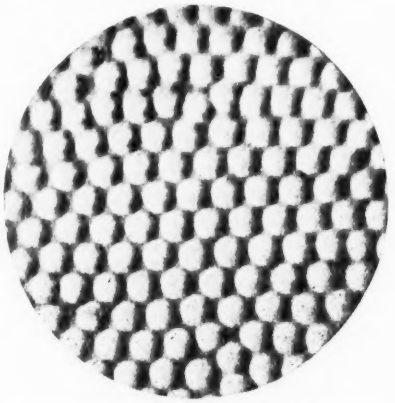


Fig. 1.—Group of "Eye-lenses" ready for the Camera. (× 200.)

To prepare the mount for the microscope, select a three-by-one slip of wood, through the centre of which a small hole has been bored. Lay the cover-glass with the object face downwards over the hole and fasten with a punched gummed label, after the manner of a French paper-mounted slide. Fix the slip firmly in the stage of the microscope. The cornea, being under the cover-glass, is protected from injury, and the facettes, facing the condenser, are in the right position for our experiment.

Next incline the microscope to a horizontal position, and fix it in its place upon the baseboard of the camera. Correct the objective to the thickness of the cover-glass, remove the mirror, and the diaphragms and stops from the substage condenser. Place a microscope lamp about ten inches from the condenser, with its flame in the optic axis of the apparatus and the bull's-eye turned aside. Withdraw the camera *pro tem.*, and proceed to focus up the middle of the object. When the field is full of sharply defined hexagons, and an image of the lamp-flame is seen

in the middle of the field, the centreing may be regarded as correct. Upon the next move depends the success of the experiment. Rack down the substage condenser until its front is about half an inch from the object, and then proceed very slowly, by means of the coarse adjustment, to rack the body tube of the microscope back from the object. The hexagons will go out of focus, and nothing can be seen. Continue the backward movement a little farther, and a number of points of light will appear, disposed in rows across the field. Focus with the fine adjustment until sharply defined, and it will be seen these points of light are inverted images of the lamp-flame, each one formed by a "lens" in the cornea. By racking the Abbé a little nearer to the stage the image in each facette will be seen to increase in size, and *vice versâ*. The focus of the objective remains fairly constant for all positions of the condenser, provided this latter is not too near. Tracing the path of light (Fig. 2) we find an image

Fig. 2.—The "Eye-lenses," B, act as Telescopes. Aërial foci at A and C.

of the radiant is formed in the principal focus of the condenser, at A, which, being at a considerable distance from the cornea, is practically in the indefinite (anterior) focus of the "eye-lenses," B. An image is again formed in the principal (posterior) focus of each "eye-lens," at C, and when this plane C is in the focus of the objective the observer at the microscope can see an image of the radiant through each facette in the field. The corneal convexities, however, are not all of the same diameter and radius, so that where a number will yield a sharp outline of the radiant, others will produce a blurred and indistinct image; but as the area covered by a half-inch objective is very small, there should be little difficulty in finding a group of facettes of similar focus. The subject to be photographed may now be considered; it should be either self-luminous or white. If the former, a window with open landscape beyond will answer, but on account of its large size must be relatively more distant from the instrument. By artificial light, opaque figures pasted on a ground-glass screen illuminated from behind may be tried, but the most satisfactory photographs are those of white subjects by reflected light, such as a bust or statuette. For the purpose of my experiment I have chosen a small chalk bust of Her Majesty the Queen, and is it not appropriate that the noblest and greatest monarch the world has ever seen should be the subject of a photograph through the most infinitesimal lens known to science? Remove the lamp, and in its stead place the object to be photographed in the optic axis of the apparatus, and, say, eighteen inches distant from the condenser; the exact distance will depend upon the amount of subject it is intended to include. It will now be necessary to bring to bear upon the subject all the available illuminating power at our disposal. Two Welsbach gaslights, being easily obtained, will do. Place one on either side of the subject in such a manner that their combined rays shall play upon the surface to be photographed. Two curved pieces of new tinplate, placed between the burners and the camera, will improve the illumination and prevent any direct light from entering the condenser. Both burners and reflectors should be as near the object as possible, but must not trespass upon the subjective field. Examine through the microscope, using the substage pinion freely, until an image of suitable size and definition is seen in each facette. Attach the camera and fine focussing rod and see that all is light-tight; the bellows may be stretched twelve to eighteen inches. In spite of the large amount of light reflected from the subject the rays transmitted by the facettes will be extremely faint, owing to their minuteness. They rarely exceed one-thousandth part of an inch in diameter, and it will be found impossible to project through them an image visible upon the ground-glass screen, though the latter be most finely obscured. But the photomicrographer will have more refined methods at his disposal to meet the greater delicacy of his work. Having removed the obscured screen from the frame, insert in its place a piece of plain glass of the same size; a spoiled negative from which the film has been stripped will answer excellently. A focussing eyeglass will now be required, and it must be so adjusted that when resting upon the plain glass screen the furthermost surface of the latter is in focus; this is best accomplished by applying with the finger scales from a moth's wing, or other minute particles upon that surface. Having arranged the eyeglass to our satisfaction, we can return the plain screen to the camera and proceed to focus the subject. To do so the operator must retire a little from the eyeglass so that its lens is seen to be full of light; this will occur when his eye and the screen are equidistant from the lens and in its principal focus. The writer uses a glass in which both distances are determined by a tube. But the images which appeared to the observer at the eyepiece of the microscope will not be in focus at the screen. We have lengthened the major conjugate focus of our apparatus and must therefore shorten the minor. By means of the fine adjustment rod, cause the objective to approach the object, keeping a sharp look-out for images through the focussing glass. It is not by any means easy to determine the exact point at which the images are best defined, and probably many "ins and outs" will be tried before a satisfactory focus is established. Presuming the objective to be of the usual achromatic type corrected for an optical focus, an isochromatic plate—the most rapid obtainable—should be employed, as the plates so designated are extra sensitive to the yellow or visual rays within the C and E lines of the spectrum. Exposure will depend, among other things, upon the desired size of the images and consequent camera stretch, and may be as much as, or more than, three hours. I shall not here enter into details of development; that formula with which the operator has had most experience is the best. Although the first plate *may* prove a success, it is advisable not to remove any of the apparatus until a satisfactory negative has been obtained.

In the distribution of visual organs nature has been most lavish to the insects, and we are filled with astonishment when we reflect that from a dragon-fly's head we could obtain twenty-five thousand perfect lenses, so minute that a million of them would not cover a square inch of surface, and yet each be capable of yielding a recognizable photograph. Had nature provided man with eyes in similar profusion, how much more could he have seen of her wisdom!

> "I, like Samson, would have eyes at every pore,
> To see the light and learn of truth the more."

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

The Discovery of Comets.—In the last number attention was drawn to the relative scarcity of new comets discovered

during the eighteen months preceding June. The latter month, however, furnished a record, for three new comets were discovered, while two known comets were redetected. It will be found on searching through catalogues of comets that no other month has ever yielded such an abundant harvest of important observations in this branch of astronomy. This is the more remarkable from the circumstance that June, with its strong twilight, is unfavourable to the detection of comets. The summary of recent discoveries may be stated as follows:—

Discoverer.	G. M. T.	Position of Comet. α	Position of Comet. δ	Perihelion Passage. Berlin Mean Time.
		° ′	° ′	
1. Coddington	June 11·722	246 14	−25 14	Sept. 13·849
2. Tebbutt	June 11·844	103 22	+11 34	Mar. 25·0
3. Perrine	June 14·974	52 15	+58 36	Aug. 16·338
4. Hussey	June 16·967	34 5	+19 43	July 4·60
5. Giacobini	June 18·526	309 7	−21 14	July 24·894

No. 2 is a reobservation of Encke's periodical comet, No. 4 of Wolf's comet. These, with Perrine's comet found on March 19th, represent a total of six comets visible, though they cannot all be seen on the northern hemisphere. Encke's and Coddington's comets have a southern declination of about forty-five degrees early in August. The latter is the second comet discovered accidentally on a photographic plate, the previous instance being that of 1892 V., which was similarly detected by Mr. Barnard. There can be no doubt that astronomical photography, when it comes to be more extensively practised, will afford the means of revealing many new comets.

Dr. Schorr has pointed out that the elements of Perrine's comet of June 14th exhibit a remarkable similarity of elements with those computed for Pons's comet of 1812 and 1884.

The following are ephemerides of three of the comets now visible:—

Comet Wolf.

Date. 1898.	R.A. h.	m.	s.	Declination. °	′	Distance in millions of miles.	Brightness.
August 6	4	42	28	+17	27·4	170	2·42
,, 10	4	52	59	+16	48·8	168	2·44
,, 14	5	3	13	+16	6·0	166	2·47
,, 18	5	13	12	+15	19·6	164	2·49
,, 22	5	22	52	+14	29·5	162	2·50
,, 26	5	32	13	+13	35·7	160	2·53
,, 30	5	41	13	+12	39·5	159	2·55

Comet Perrine (March 19th).

Date. 1898.	R.A. h.	m.	s.	Declination. °	′	″	Brightness.
August 2	5	58	10	+52	37	15	0·07
,, 6	6	3	44	+52	22	31	0·06
,, 10	6	8	51	+52	8	45	0·06
,, 14	6	13	30	+51	56	4	0·06
,, 18	6	17	40	+51	44	29	0·06
,, 22	6	21	22	+51	34	2	0·05
,, 26	6	24	35	+51	24	43	0·05
,, 30	6	27	21	+51	16	32	0·05

The distance from the earth varies very little from two hundred and seventy millions of miles during the month.

Comet Perrine (June 14th).

Date. 1898.	R.A. h.	m.	Declination. °	′	Distance in millions of miles.	Brightness.
August 14	8	9·0	+11	56	135	8·4
,, 30	9	17·2	− 9	14	134	7·0
September 15	10	36·0	−24	43	145	3·7
October 1	11	57·2	−37	44	166	1·8
,, 17	13	11·7	−43	29	193	0·9

At the middle of August this comet will be only about twenty-three degrees west of the sun, so the conditions affecting its visibility will be very unfavourable. It is moving rapidly southwards and will soon be lost to observers in our latitude.

In addition to the various comets mentioned, astronomers are expecting the return of Tempel's comet (1867 II.), but its detection has not yet been announced; and, in view of the fact that its distance is increasing, and that it escaped observation at the last three returns, there seems but a slender prospect that it will be observed during the present year.

August Meteors.—With the return of the Perseids, meteoric observers have plenty of attractive work in hand. Meteors are abundant, and the season is a convenient one for night work of this kind. This year the moon will be full on the morning of August 2nd, so that in the early part of the month the sky will be very light, and only the larger Perseids are likely to be observed. Moonlight will, in fact, prove rather a serious hindrance to observation during the first eight or nine nights, for our satellite moves so rapidly northwards that she rises very little later on successive evenings. Her age and times of rising, at the most important period, are as follows:—

1898.	Age at noon. d.	h.	Time of rising. h.	m.	
August 8 ...	20	16·2	9	36	p.m.
,, 9 ...	21	16·2	10	4	,,
,, 10 ...	22	16·2	10	41	,,
,, 11 ...	23	16·2	11	26	,,
,, 12 ...	24	16·2	12	20	,,

The last quarter occurs on the evening of the 9th, so that on the night of the 10th, when the maximum of the shower is usually attained, the light of the moon will have declined so much as to be comparatively feeble. In the last number an ephemeris was given of the Perseid radiant to the end of July, and the following is a continuation of it to August 18th, when the display will be nearly exhausted:—

	°	°		°	°
August 1 ...	35	+ 55	August 10 ...	45	+ 57
,, 2 ...	36	+ 55	,, 11 ...	46	+ 57
,, 3 ...	37	+ 56	,, 12 ...	47	+ 57
,, 4 ...	38	+ 56	,, 13 ...	49	+ 58
,, 5 ...	39	+ 56	,, 14 ...	50	+ 58
,, 6 ...	40	+ 56	,, 15 ...	51	+ 58
,, 7 ...	41	+ 57	,, 16 ...	53	+ 59
,, 8 ...	42	+ 57	,, 17 ...	54	+ 59
,, 9 ...	44	+ 57	,, 18 ...	55	+ 59

It will be interesting to test the accuracy of this ephemeris by careful observations made on the individual nights mentioned. Notwithstanding the interference of the moon the Perseids are usually so active, even at the early part of August, that the radiant point may be readily derived.

Bright Meteors.—On June 5th, about 10h., a meteor brighter than Vega travelled from β Ophiuchi to β Lyræ. It was bluish white in colour, and left a trail of sparks. Observer: Mr. Albert Ashby, West Croydon.

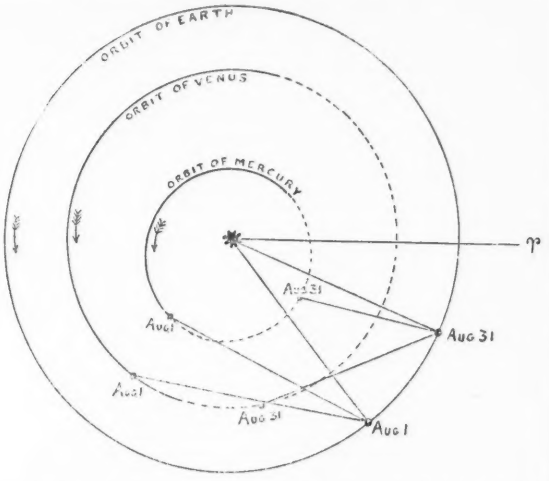
On June 26th, 11h. 24¼m., a meteor, about as bright as a first magnitude star, appeared in a barren part of the sky, eight degrees north of the star σ Sagittarii. It pursued an upward course, vanishing exactly one degree west of ϑ Serpentis, and during its flight increased so much in brilliancy that at the end it was equal to Venus at her best. The meteor was bluish white in colour, and moved slowly along its path in about five seconds. Observer: Rev. S. J. Johnson, Bridport, Dorset.

THE FACE OF THE SKY FOR AUGUST.

By A. FOWLER, F.R.A.S.

SUNSPOT activity is apparently approaching a minimum, so that perhaps few spots of considerable magnitude may be expected. Still, abnormal conditions have been noted in the past, and careful observation may not go unrewarded. Bright faculæ and coarse granulation of the general surface have been recently noted.

Mercury will be an evening star, reaching its greatest easterly elongation of 27° 22′ at 3h. A.M. on the **9th**. On that day he sets at 8h. 13m. P.M.—that is, only forty minutes after sunset—so that the planet is not particularly well situated for observation in this country. The apparent diameter on the **1st** is 6·6″; on the **9th**, 7·4″; on the **15th**, 8·1″. At noon on the **1st** the horizontal parallax is 8·8″, the distance of the planet from the Earth thus being identical with that of the Sun.



Orbital Movements of Earth, Venus, and Mercury during August, 1898. (The dotted lines represent the parts below the ecliptic.)

Venus is an evening star throughout the month, but the southerly movement will render her appearance less striking to the naked eye than might be expected. During the month her declination changes from 4° 49′ N. to 10° 16′ S., and her apparent diameter increases from 15·6″ to 20 0″. On the **19th** at 6h. P.M. she will be in conjunction with Jupiter, 1° 51′ to the south; on the **21st** at 8h. A.M. she will be in conjunction with the Moon, the planet being 5° 3′ to the north. The planet will set at 8h. 52m. P.M. on the **9th**, seventy-nine minutes after sunset, and at 8h. 2m. P.M. on the **29th**, seventy minutes after sunset. At the middle of the month 0·65 of the disc will be illuminated.

Mars is still so distant that only large instruments are likely to reveal any detail. As a matter of comparison it may be of interest to note that at the favourable opposition of 1892 his horizontal parallax was 23·4″, corresponding to a distance from the Earth of 34,935,000 miles, while at the middle of August it will be 5·6″, corresponding to a distance of 145,980,000 miles. At the middle of August his apparent diameter is only 6·0″. On the **1st** he will be 5° north of Aldebaran, and will travel eastwards, until on the **23rd** he will be about 2° north of ζ Tauri. He will rise shortly before midnight in the earlier part of the month, and about 11h. P.M. towards the end.

Jupiter may be observed shortly after sunset during the early part of the month. He passes eastward from near η Virginis on the **1st**, through a point less than 2° south of γ Virginis on the **20th**. The polar diameter diminishes from 30·6″ to 29·0″.

Saturn, in Scorpio, may still be observed in the early evening. On the **9th** he sets at 11h. 21m. P.M., and on the **29th** at 10h. 3m. P.M. He will be stationary on the **9th** and in quadrature on the **29th**. The outer major and minor axes of the outer ring vary respectively from 40·02″ to 38·71″ and 17·37″ to 16·87″ from the **8th** to the **28th**; during the same period the corresponding dimensions of the inner bright ring vary from 25·47″ to 24·64″ and 11·06″ to 10·74″ respectively; and the apparent polar diameter of the planet diminishes from 16·0″ to 15·4″ between the same dates. The northern surface of the ring is visible.

Uranus remains a little east of λ Libræ, forming an almost equilateral triangle with β and δ Scorpii. The planet is very low in the sky, and even at the beginning of the month sets before midnight. The apparent diameter diminishes from 3·8″ to 3·6″ during the month.

Neptune describes a short eastward path in Taurus, from about 1° to 1½° north-east of ζ Tauri. At the beginning of the month he does not rise until after midnight, but towards the end he will rise shortly before 11 P.M.

The Moon will be full on the **2nd** at 4h. 29m. A.M.; she will enter the last quarter at 6h. 13m. A.M. on the **9th**; will be new at 10h. 35m. A.M. on the **17th**; enter the first quarter at 8h. 32m. P.M. on the **24th**; and will again be full at 12h. 51m. P.M. on the **31st**.

A conveniently observable minimum of Algol is due about 9h. 44m. P.M. on the **23rd**. Other minima, at less convenient times, will occur on the **3rd** at 8h. 2m. P.M., and on the **20th** at 12h. 55m. P.M.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of July Problems.

No. 1.

(By A. G. Fellows.)

1. Kt to Q7, and mates next move.

CORRECT SOLUTIONS received from Alpha, W. de P. Crousaz, H. S. Brandreth, J. M'Robert.

No. 2.

(By A. C. Challenger.)

Speaking from memory we believe that the author's intended solution was 1. R to B6. Our trustworthy correspondent "Alpha" claims that this attempt is frustrated by 1. . . . B×P. We must apologize for our inability to verify this, having unfortunately mislaid the current number of KNOWLEDGE. W. de P. Crousaz also claims "no solution."

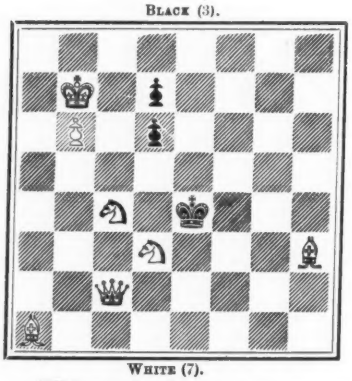
B. G. Laws.—Many thanks for the problem, a copy of which shall be sent you next month. We congratulate the problem department of the *British Chess Magazine*.

PROBLEMS.

By J. Nield (Crompton).

No. 1.

BLACK (3).

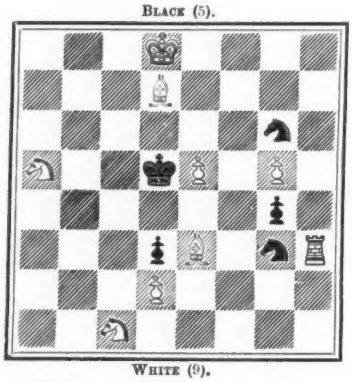


WHITE (7).

White mates in two moves.

No. 2.

BLACK (5).



WHITE (9).

White mates in three moves.

CHESS INTELLIGENCE.

We much regret to have to announce the death of Mr. James Rayner, the problem editor of the *British Chess Magazine*, and for many years one of the strongest players in the North of England. Mr. Rayner was also certainly one of the finest English problem composers, and his death at the early age of thirty-nine is a great loss to the chess world. He is succeeded in the problem department of the *British Chess Magazine* by Mr. B. C. Laws, who formerly conducted the problem department of the *Chess Monthly*.

The Vienna international tournament still continues. Messrs. Pillsbury, Tarrasch, Janowski, and Steinitz are leading at present. Of the English representatives, Mr. Burn is doing best. Herr Schwarz retired after playing eight games only, and his score was cancelled. The Congress of the German Chess Association begins at Cologne on July 31st.

There is little chess of importance in England at this season, but Messrs. Lee and Teichmann are engaged in a short match.

The amateur tournament of the Southern Counties Chess Union begins at Salisbury on Monday, September 5th, and will be continued, if necessary, till September 14th. All entries must reach Mr. C. J. Woodrow, 3, Castle Street, Salisbury, on or before August 31st, and must be accompanied by entrance fees. Further particulars may be had on application to the above address. Messrs. Bird and Blackburne will probably be present during the meeting.

Game played in the Vienna tournament :—

"Kisseritzky Gambit."

WHITE. (C. A. Walbrodt.)	BLACK. (A. Burn.)
1. P to K4	1. P to K4
2. P to KB4	2. P×P
3. Kt to KB3	3. P to KKt4
4. P to KR4	4. P to Kt5
5. Kt to K5	5. B to Kt2
6. P to Q4	6. Kt to KB3
7. Kt×KtP	7. Kt×P
8. B×P	8. Q to K2
9. Q to K2	9. P to Q3
10. Kt to K3	10. B to K3
11. P to B3	11. Castles
12. Q to B3	12. P to Q4
13. B to Q3	13. P to QB4
14. B×Kt	14. P×B
15. Q to Kt3	15. P×P
16. B to Q6	16. Q to Qsq
17. P×P	17. R to Ksq
18. P to Q5	18. B to Q2
19. Kt to B3	19. Kt to R3
20. Castles (KR)	20. R to QBsq
21. R to B2	21. P to B3
22. QR to KBsq	22. K to Rsq
23. P to R5	23. Kt to B4
24. P to R6	24. B×P
25. R×P	25. B×Kt2
26. R to B7	26. B to Q5
27. R×Pch	27. Resigns.

KNOWLEDGE, PUBLISHED MONTHLY.

Contents of No. 152 (June).

	PAGE
The Mourne Mountains. By Grenville A. J. Cole, M.R.I.A., F.G.S. (*Illustrated*)	121
The Petroleum Industry. By George T. Holloway, ASSOC. R.C.S. (LOND.), F.I.C. (*Illustrated*)	124
Economic Botany. By John R. Jackson, A.L.S., etc.	126
Weather Accounts. By Alex. B. McDowall, M.A. (*Illustrated*)	128
The Prismatic Camera at the Recent Eclipse. By J. Evershed, F.R.A.S.	130
Occultation of 26 Arietis observed Photographically. By Edward C. Pickering. (*Illustrated*)	133
Notices of Books	134
Letters	136
Science Notes	136
Africa and its Animals. By R. Lydekker, B.A., F.R.S.	137
The Vinegar Fly and the Vinegar Mite. By C. Ainsworth Mitchell, B.A., F.I.C. (*Illustrated*)	139
A Classic Legacy of Agriculture. By John Mills	140
Notes on Comets and Meteors. By W. F. Denning, F.R.A.S.	142
The Face of the Sky for June. By Herbert Sadler, F.R.A.S.	143
Chess Column. By C. D. Locock	143
PLATE.—Eclipse Spectra.	

Contents of No. 153 (July).

	PAGE
The Karkinokosm, or World of Crustacea.—IV. By the Rev. Thomas R. R. Stebbing, M.A., F.R.S., F.L.S. (*Illustrated*)	145
A Classic Legacy of Agriculture.—II. By John Mills. (*Illustrated*)	148
"The Mimic Fires of Ocean." By G. Clarke Nuttall, B.SC.	150
The Petroleum Industry.—II. By George T. Holloway, ASSOC. R.C.S. (LOND.), F.I.C. (*Illustrated*)	151
On the Eclipse Theory of Variable Stars. By Lieut.-Colonel E. E. Markwick, F.R.A.S. (*Illustrated*)	153
The Recent Eclipse.—The Lick Photographs of the Corona. By E. Walter Maunder, F.R.A.S.	155
Notices of Books	156
Obituary	158
Letters	159
Science Notes (*Illustrated*)	159
Self-Irrigation in Plants. By the Rev. Alex. S. Wilson, M.A., B.SC. (*Illustrated*)	160
British Ornithological Notes	162
Botanical Studies.—IV. Mnium. By A. Vaughan Jennings, F.L.S., F.G.S. (*Illustrated*)	163
Notes on Comets and Meteors. By W. F. Denning, F.R.A.S.	166
The Face of the Sky for July. By A. Fowler, F.R.A.S.	167
Chess Column. By C. D. Locock	167
PLATE.—The Lick Photographs of the Corona.	

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